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ABSTRACT

Twenty-eight lesson plans for the second year of a four-year electrical apprentice technical training program are presented in this instructor's manual. Also included are student worksheets and information sheets for each lesson, and copies of unit tests. (Answers to the worksheets and tests are provided.) The lesson plans are generally organized into four steps: introducing the lesson, presenting the lesson (e.g., demonstration), student application (use of worksheets), and checking and follow-up (checking answers to worksheets). Some of the lesson topics are electrical systems, single phase transformers, grounded conductors, outside branch circuits, three phase motors, lighting fixtures, sample house plans, and outlet circuiting. (Student worksheets and information sheets for this training program are also available separately--CE 018 356. Other related documents, CE 018 350-360, include a basic mathematics review, jobsite supervisor's manual, and instructor's manuals and worksheets for the other three years of the program.) (JE)

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ED 160880

INSTRUCTOR'S MANUAL
FOR
ELECTRICAL APPRENTICE
TECHNICAL TRAINING

SERIES NO B

(SECOND YEAR)

Revised to meet 1978 Electrical Code

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

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PROGRAM DEVELOPMENT
DEPARTMENT OF COMMUNITY COLLEGES
RALEIGH, NORTH CAROLINA

CE 018 355

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FOREWORD

The apprenticeship programs offered in North Carolina are important phases of the total educational program for industry in the state. The program of education for modern apprenticeship includes two distinct phases. The first phase is "on-the-job training." The student is employed by a firm in which duties are specifically assigned to enhance ones learning in the field of study. These experiences are planned and supervised so that the individuals will progress through the apprenticeship phase to that of the journeyman. The second phase of the program of education is termed "related instruction." In this phase the apprentice is provided the technical and theoretical foundation subjects that help one to learn the trade thoroughly and accurately. This portion is usually taught through evening school, but in some cases may be done through correspondence courses.

The North Carolina Department of Community Colleges, through the Program Development Section, has the responsibility for developing and making available the instructional materials that provide the learner with a sound educational program which is effective and appropriate to the method in which the materials are being utilized. The department has available these materials for the students, as well as support material for the instructor who teaches or who acts as counselor in conducting the related classes.

Roger G. Worthington

Roger G. Worthington, Director
Program Development

Ben E. Fountain, Jr.

Ben E. Fountain, Jr., State President
Department of Community Colleges

PREFACE

The Program Development Section of the Department of Community Colleges has the responsibility for making available the related instructional materials required for use in occupational programs offered by the various institutions. This responsibility is accomplished by working with advisory committees and consultants representing each of the occupations in determining the needs and in developing the materials required to meet these needs.

These information sheets and worksheets have been prepared to provide specific assignments for studying related topics necessary in the training of electrical apprentices. An effort was made to develop the schedule to follow as the apprentice progresses with training. It will also enable the apprentice to know what skills and knowledges will be required. The objective of this program is to aid the instructor and employer in providing experiences necessary to develop not only a competent worker in the electrical field, but also, a well-rounded citizen.

This workbook includes assignment sheets and information sheets for the electrical apprentice to use in searching out related information. The worksheets contain problems to solve, questions to answer diagrams to draw, and blueprints to consult. The apprentice should study the references (assigned by the instructor) before attempting to answer the questions or solve the problems.

In actual use of these lessons, instructors should feel free to modify their application of the material to conform with local needs. For example, there may be certain sections of the Code to teach because the apprentices are working with special installations. Thus, the instructor should lead a discussion on materials that applies to these situations. In other classes, the instructor may need to spend more time with the students on topics dealing with mathematics than with blueprint reading. In any event, the minimum class time for related material is 144 hours per year. It is sincerely hoped that the assignment sheets are used correctly so that apprentices can gain maximum benefits from their related studies.

ELECTRICAL APPRENTICESHIP TECHNICAL TRAINING

ACKNOWLEDGMENTS

Questions and problems for the Lesson Topics were prepared in July, 1964 by:

W.F. Humbert, III, Electrical Engineer
Winston-Salem, North Carolina

The Instructor's Manuals, Information and Orientation Sheets were developed by:

Howard E. Hedinger, Educational Consultant
Department of Community Colleges
Raleigh, North Carolina

The manual was revised in 1967, 1971, and 1975.

REVISION COMMITTEE 1978

Mr. Jack McKeel, Chairman - Instructor, Jamestown, North Carolina
Mr. F. Lloyd Willard, Electrical Inspector High Point, North Carolina
Dr. Larry W. Fuqua, Assistant Director for Vocational & Apprenticeship Programs, Department of Community Colleges, Program Development Raleigh, North Carolina

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ASSIGNMENT REFERENCES

NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
		*Note # 1	*Note # 4	*Note # 2	*Note # 3	*Note # 5
Electrical Systems	B-1			200, 210	3-19 thru 3-29	
A. C. Instruments and Their Use	B-2		1-62 thru 1-97, 1-108, 1-118 thru 1-119, 3-22, 5-75		1-60 thru 1-218	Basic Math Pg. 356-368
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Fixed Electric Space Heating	B-6			424, 210,250	9-394 thru 405	
Outdoor De-Icing and Snow Melting Equipment	B-7			426, 210,250	9-405 thru 410	

*Note # 1: Page Numbers Listed
*Note # 2: Article Numbers Listed

*Note #3: Division and Section Numbers Listed
*Note #4: Chapter and Page Numbers Listed
*Note #5: Basic Math References in last column are 3rd Edition, 1972

NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N. E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
General Installation Requirements	B-8			110		
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Branch Circuits	B-11			210	3-30 thru 55	
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Feeders and Branch Circuit Calculations	B-13			210 215, 220	3-30 thru 3-55	
Services	B-14			230, 250	9-346 thru 356	
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Single Phase Motors	B-18		5-97 thru 5-112	430	7-187 thru 201	Basic Math Pg. 398
Three Phase Motors	B-19		5-97 thru 5-112	430	7-144 thru 186	

NAME (TITLE)	LESSON NO.	BASIC MATH	BASIC ELECTRICITY	N.E. CODE	AMERICAN ELECTRICIAN'S HANDBOOK	OTHER MATERIALS
Motor Circuits	B-20			430	7-421 thru 7-442	
Motor Circuit Calculations	B-21			430		
Lighting Fixtures	B-22			410,402		
Swimming and Wading Pools	B-23			680		
Cranes, Hoists, Elevators, Dumbwaiters, and Escalators	B-24			610 620	9-357 thru 9-374	
Emergency Systems	B-25			700, 750		
Mobile Homes, Recreational Vehicles, and Parks	B-26			550 551		
Sample House Plans	B-27					

ELECTRICAL STEEL RACEWAYS DESIGN MANUAL 1978 EDITION IS AVAILABLE FROM:
AMERICAN IRON AND STEEL INSTITUTE
1000 SIXTEENTH STREET, N.W.
WASHINGTON, D.C. 20036

MANUAL CAN BE USED AS A SUPPLEMENTARY TEACHING AID.

ELECTRICAL APPRENTICE TECHNICAL TRAINING
(GUIDELINES)

TO THE INSTRUCTOR:

- It is suggested that the instructor use an Orientation Sheet to help him to become acquainted with the apprentice. Name, address, birthplace, education, employers and types of work, sponsoring employer, home situation (marital status and number of children), hobbies, likes and dislikes, etc., should be included.

- The Instructor's Manual and the Assignment Sheets or Worksheets have been revised to update the materials. Lessons are arranged by topics to reflect electrical installation in compliance to the N. E. Code.

- The brief Lesson Plans should act as a guide in conducting classes and in organizing your program. It is recommended that you write out your own plans, using illustrations that are familiar and timely.

- The Information Sheets and Worksheets are designed to help the apprentice master the related technical materials found in textbooks and references. The answer sheets are included in the Instructor's Manual.

- The second year (Series B) of the course in Technical Training for Electrical Apprentices is designed, as was the first year, to make it easier for the instructor. The lesson outlines should help the instructor lead his classes gradually into the more complex phases of the study of Electrical Installation as required by the National Electrical Code.

- It should be noted by the instructor that:

    1. Topics on basic mathematical principles were reviewed and other applied topics were introduced during the first year (Series A). The second year (Series B) contains no topics specifically on mathematical subjects. Yet the instructor will realize that additional practice in handling equations will be necessary for most apprentices by the time they begin to study alternating current. It will be essential for the instructor to pay special attention to these mathematical tools in order to be sure that the electrical theory will be completely understandable to the apprentices. In the event that some of the apprentices are weak in mathematics, the instructor should make additional assignments in math problems, using the Learning Resource facilities at the institution or give special individual help.

2. In this course, the topics on the National Electrical Code will be studied in terms of wiring methods. It is hoped that by studying the Code along with other subjects each year will help create interest and will be better applied to job situations.

3. There is a suggested list of audiovisual aids; however, the instructor should use any other aids available, but be sure to order them in ample time. It is hoped that the instructors will not have too much difficulty obtaining particular aids at the time they need them.

- In the event the instructor uses individualized self-pacing methods where the students work at their own pace, he may need more programmed materials. Consult the Learning Lab for help in such instances.

- Assignments and page references have been placed on a sheet following the Table of Contents. This sheet can be revised easier than all the lesson sheets when textbooks are changed. It is suggested that the references be written on the chalkboard for each assignment.

- Each apprentice or student should have a large three-ring notebook to keep the lesson sheets, assignments, and notes.

- Answer sheets for both the Worksheets and the Tests have been placed in the Instructor's Manual for your use.

- Corrections for the Worksheets will be attached or listed in the Instructor's Manual. Please call attention to errors in printing when you make the assignment.

- The Four-Step Outline

  Each lesson plan is outlined into the "four-step" method of instruction and should assist you in presenting the lessons. In group instruction, it is recommended that the class period include the following:

  STEP I - INTRODUCING THE LESSON:
  Call attention to interesting facts concerning the subject.

  STEP II - PRESENTING THE LESSON:
  Demonstrate the use of necessary tools, materials, problems, and experiments. A well-presented lesson will require the student to do a minimum of reading in the assigned texts. NOTE: When adequate equipment is provided, each student can perform the experiments individually. Show films or slides related to the subject. Discuss problems encountered on the job.

STEP III - APPLICATION:
Make use of the assignment sheets prepared for each lesson. The assignments serve not only as a valuable aid to the learner, but also indicate to the instructor how well the lesson was taught.

STEP IV - CHECKING AND FOLLOW-UP:
Check the worksheets with aid of answer sheets. This can be done quickly by the instructor or by exchange of papers in class. Return the papers to the students to correct mistakes and give individual help to those who need it. Call attention to common errors and discuss the problems or questions which were incorrect.

NOTE: Make assignments for the next week.

- Testing Procedures:

1. Short tests can be given each week on the lesson or the previous assignment.

2. A thorough test should be given shortly after completing a unit or group of lessons. This test should cover six weeks work or less.

3. A good comprehensive test administered at the end of the course will act as a gage of progress for the year. Some questions using charts, tables, and National Electrical Code can be of the "open book" type.

4. All tests should be checked in detail, reviewed in class, and returned to you. Tests should be retained by you and the committee as a part of the student's record.

- Please note that the assignment references for textbooks list the page numbers.

The National Electrical Code references are "Articles."

The American Electrician's Handbook lists the Division and Section; these are not the page numbers.

- Textbooks:

NOTE: Book stores at the institutions can order the textbooks and receive the school discount.

1. Basic Mathematics for Electricity and Electronics by Singer; 3rd Edition, 1972; $10.50; McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. 10036.

2. Basic Electricity by Van Valkenburgh, Nooger, and Neville; 1st Edition, 1954; #0033 5 volumes paperback - 3.50 each; #0039 1 volume cloth - $16.50; less discount; Haden Book Company, Inc., 116 West 14th Street, New York, N.Y. 10011

3. American Electrician's Handbook by Croft, Carr, and Watt; 10th Edition, 1972; McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N.Y. 10036.

4. National Electrical Code, Latest Edition; Approximately $5.50 National Electrical Contractors Association, 700 O.F.C. Building, 1730 Rhode Island Avenue, N.W., Washington, D.C. 20036.

5. Steel Electrical Raceways Design Mannual; based on 1978 N.E. Code. Approximately $2.00; American Iron and Steel Institute, 150 E 42nd Street, New York, N.Y. 10017.

INSTRUCTIONAL MATERIALS:

The necessary materials should be ordered from the Department of Community Colleges, Program Development Section, Raleigh, N.C. 27602.

1. Instructor's Manual - Second Year - Series B
2. Student Information and Worksheets - Second Year - Series B
3. Mathematics Pretest
4. Basic Mathematics Review
5. MAT 1111 - Slide Rule
6. Unit Tests (Series B Copy of tests without answers is included in Instructor's Manual; please have your own student tests printed.

ELECTRICAL SYSTEMS

DESIRED RESULTS:

1. To review reasons for providing separate circuits for lamps and motors.
2. To be able to sketch and trace various three-wire Delta and four-wire Wye systems.

INTRODUCTION:

There are several systems that may be used for distributing electrical energy over the various arrangement of circuits. It is generally not good practice to supply lamps and motors from the same circuit unless the motors are small, fractional horsepower sizes.

Most power utility companies require a three-phase service installation when the connected motor load is in excess of 5 horsepower. Most three-phase motors of one horsepower or larger are cheaper than single-phase motors of equal rating. Furthermore, the three-phase motor is easier to maintain than a single-phase motor. The three-phase motor does not have a centrifugal switch or a commutator that require a great deal of maintenance.

PRESENTING THE LESSON:

Demonstrate:

1. A Wye connection on the chalkboard.
2. A Delta system on the chalkboard.
3. Discuss line and phase voltages and current relationships of each system.
4. Give applications of Wye and Delta connections
   a. Generators, motors, and transformers.
   b. The three and four wire transmission lines.

APPLICATION:

Have the students complete the Assignment Sheet.

CHECKING AND FOLLOW-UP:

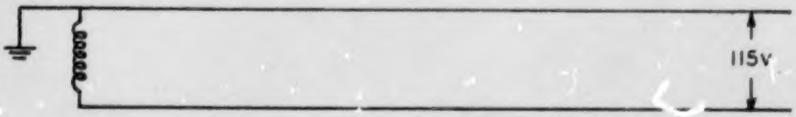
Check the answers and return to the students for correction.

ELECTRICAL SYSTEMS

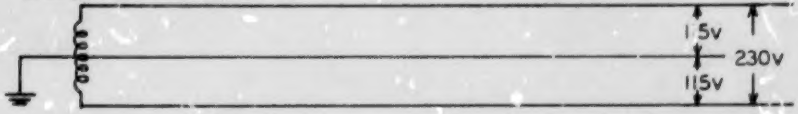
The following four pages of Information Sheets contain the several voltage classifications, nomenclature, and preferred ratings.

TYPES OF A.C. DISTRIBUTION 600 VOLTS OR LESS

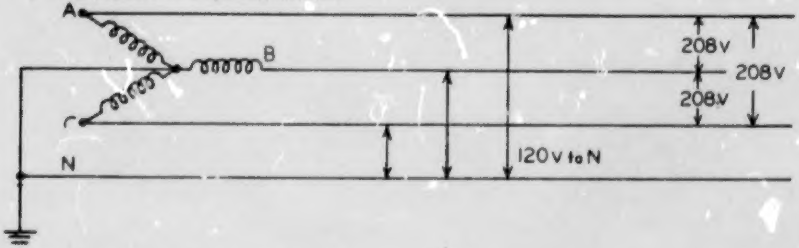
a. Single phase, 2-wire, 115 volts



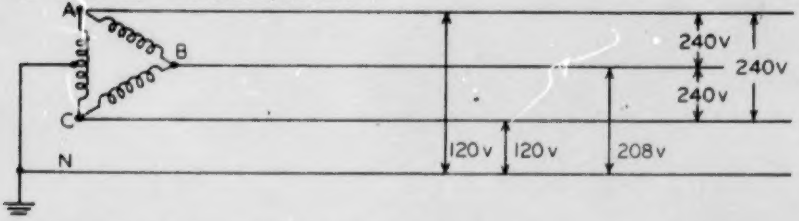
b. Single phase, 3-wire 115/230 volts


115v
230v
115v

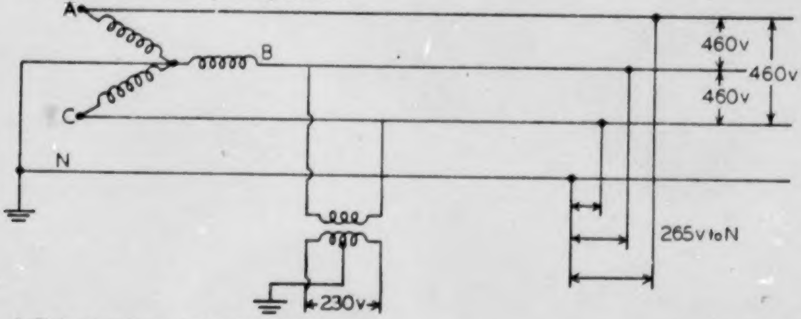
c. Three phase, 4-wire wye 120/208 volts


A
B
C
N
208v
208v
208v
120v to N

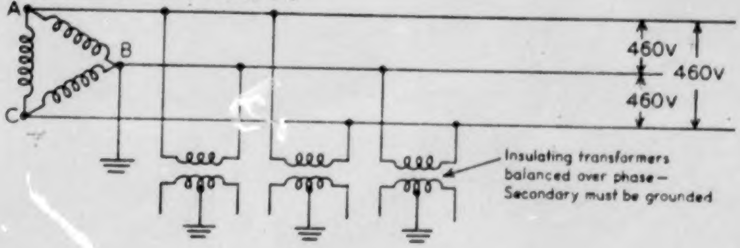
d. Three phase, 4-wire delta 120/240 volts


A
B
C
N
240v
240v
240v
120v
120v
208v

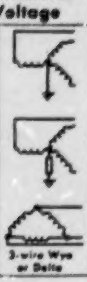
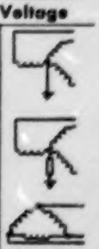
e. Three phase, 4-wire wye 460/265 volts


A
B
C
N
460v
460v
460v
265v to N
230v

f. Three phase, 3 wire delta 230 or 460 volts


A
B
C
460v
460v
460v
Insulating transformers
balanced over phase—
Secondary must be grounded

Preferred System Voltage Nomenclature, Three-Phase Systems

Industrial and Commercial Power Systems						Electrical Utility Power Systems	
Preferred Nominal System Voltage		Voltage Zones				Preferred Nominal System Voltage	
		Favorable Zone		Tolerable Zone			
4-wire Wye	 3-wire Wye or Delta	Minimum	Maximum	Minimum	Maximum	4-wire Wye	 3-wire Wye or Delta

VOLTAGES AT POINT OF UTILIZATION EQUIPMENT

Low-Voltage Systems

208Y/120		197Y/114 (94.7%)	216Y/125 (103.8%)	193Y/111 (92.4%)	220Y/127 (105.8%)	120/208Y	
	230	210 (91.3%)	240 (104.3%)	200 (87.0%)	250 (108.7%)		230
	460	420 (91.3%)	480 (104.3%)	400 (87.0%)	500 (108.7%)		460
460Y/265(b)		434Y/250 (94.3%)	480Y/277 (104.3%)	422Y/244 (91.7%)	500Y/288 (108.7%)	265/460Y(b)	
	575	525 (91.3%)	600 (104.3%)	500 (87.0%)	625 (108.7%)		575

Medium-Voltage Systems

	2400	2200 (91.7%)	2450 (102.1%)	2100 (87.5%)	2540 (105.8%)		2400
	4160	3810 (91.7%)	4240 (102.1%)	3630 (87.5%)	4400 (105.8%)		4160
	4800	4400 (91.7%)	4900 (102.1%)	4200 (87.5%)	5080 (105.8%)		4800
	6900	6320 (91.7%)	7050 (102.1%)	6040 (87.5%)	7300 (105.8%)		6900
	13,800	12,650 (91.7%)	14,100 (102.1%)	12,080 (87.5%)	14,600 (105.8%)		

PRIMARY VOLTAGES AT DISTRIBUTION TRANSFORMERS

Medium-Voltage Systems

		2300 (95.8%)	2500 (104.2%)	2200 (91.7%)	2600 (108.3%)		2400
		2300/4000Y (95.8%)	2500/4330Y (104.2%)	2200/3810Y (91.7%)	2600/4500Y (108.3%)	2400/4160Y	
		4600 (95.3%)	5000 (104.2%)	4400 (91.7%)	5200 (108.3%)		4800
		6900 (95.8%)	7500 (104.2%)	6600 (91.7%)	7800 (108.3%)		7200
		4600/8000Y (95.8%)	5000/8660Y (104.2%)	4400/7620Y (91.7%)	5200/9000Y (108.3%)	4800/8320Y	
		11,000 (91.6%)	12,500 (104.2%)	10,500 (87.4%)	13,000 (108.3%)		12,000
		6900/12,000Y (95.8%)	7500/13,000Y (104.2%)	6600/11,450Y (91.7%)	7800/13,500Y (108.3%)	7200/12,470Y	13,200
		12,600 (95.4%)	13,800 (104.5%)	12,100 (91.7%)	14,300 (108.3%)		
		7270/12,600Y (95.4%)	7960/13,800Y (104.5%)	7000/12,100Y (91.7%)	8250/14,300Y (108.3%)	7620/13,200Y	
		13,000 (90.3%)	14,500 (100.7%)	12,600 (87.4%)	15,000 (104.2%)		14,400

VOLTAGES AT SUBSTATIONS OR ON SUBTRANSMISSION OR TRANSMISSION SYSTEMS

Medium-Voltage Systems

	2400	2300 (95.8%)	2600 (108.3%)	2200 (91.7%)	2750 (114.6%)		2400
	4160	4000 (95.8%)	4500 (108.3%)	3810 (91.7%)	4760 (114.6%)		
		2300/4000Y (95.8%)	2600/4500Y (108.3%)	2200/3910Y (91.7%)	2750/4760Y (114.6%)	2400/4160Y	
	4800	4600 (95.8%)	5200 (108.3%)	4400 (91.7%)	5500 (114.6%)		4800
	6900	6600 (95.8%)	7470 (108.3%)	6320 (91.7%)	7900 (114.6%)		
		6900 (95.8%)	7800 (108.3%)	6600 (91.7%)	8250 (114.6%)		7200
		4600/8000Y (95.8%)	5200/9000Y (108.3%)	4400/7620Y (91.7%)	5500/9520Y (114.6%)	4800/8320Y	
		11,000 (91.6%)	13,000 (108.3%)	10,500 (87.4%)	13,200 (110.0%)		12,000
		6900/12,000Y (95.8%)	7800/13,500Y (108.3%)	6600/11,450Y (91.7%)	7920/13,700Y (110.0%)	7200/12,470Y	
		12,600 (95.4%)	14,300 (108.3%)	12,100 (91.7%)	14,500 (110.0%)		13,200
		7270/12,600Y (95.4%)	8250/14,300Y (108.3%)	7000/12,100Y (91.7%)	8320/14,500Y (110.0%)	7620/13,200Y	
	13,800	13,200 (95.8%)	14,950 (108.3%)	12,630 (91.7%)	15,000 (108.4%)		
		13,000 (90.3%)	15,000 (104.2%)	12,600 (87.4%)	15,500 (107.7%)		14,400

High-Voltage Systems

	23,000	See Note 1	See Note 1	20,400 (88.7%)	25,800 (112.2%)		23,000
	27,600			24,500 (88.7%)	31,000 (112.3%)		27,600
	34,500			30,600 (88.7%)	38,000 (110.0%)		34,500
	46,000			40,000 (86.9%)	48,300 (105.0%)		46,000
	69,000			60,000 (86.9%)	72,500 (105.1%)		69,000
	115,000			100,000 (86.9%)	121,000 (105.1%)		115,000
	138,000			120,000 (86.7%)	145,000 (105.0%)		138,000
	161,000			140,000 (86.9%)	169,000 (105.0%)		161,000
	230,000			200,000 (86.9%)	242,000 (105.2%)		230,000

Note 1: For systems with nominal voltages above 13,800 volts, the designation of a "favorable zone" has been omitted as being somewhat less necessary than for the lower voltages.

Preferred System Voltage Nomenclature, Single Phase Systems

Industrial and Commercial Power Systems						Electrical Utility Power Systems	
Preferred Nominal System Voltage		Voltage Zones				Preferred Nominal System Voltage	
		Favorable Zone		Tolerable Zone			
3-wire	2-wire	Minimum	Maximum	Minimum	Maximum	3-wire	2-wire

VOLTAGES AT POINT OF UTILIZATION EQUIPMENT

Low-Voltage Systems

120/240	120	110 (91.7%)	125 (104.2%)	107 (89.2%)	127 (105.8%)		120
		110/220 (91.7%)	125/250 (104.2%)	107/214 (89.2%)	127/254 (105.8%)	120/240	
		220/440 (91.7%)	250/500 (104.2%)	214/428 (89.2%)	254/508 (105.8%)	240/480	

Preferred Voltage Ratings for Alternating-Current Equipment

Preferred Nominal System Voltage	Generator Rated Voltage	Transformer Secondary Rated Voltage	Transformer Primary Rated Voltage	Switchgear Nominal Rated Voltage	Capacitor Rated Voltage	Motor and Control Rated Voltage	Ballast Rated Voltage
Single-Phase Systems and Single-Phase Components Applied on Three-Phase Systems							
120	120	120	120	120		115	120
120/240	120/240	120/240	240	240	230 or 240	230	236 or 240
208Y/120, 3-phase	125/216Y, 3-phase	216Y/125, 3-phase	120	240	230 or 240	115*	120*
460Y/265, 3-phase	277/480Y, 3-phase	480Y/277, 3-phase	480	480	460 or 480		265* or 277*
Three-Phase Low-Voltage Systems							
208Y/120	125/216Y	216Y/125	208	240	216 or 230 or 240	208 or 220	208†
230	139/240Y	240Y/139 or 240	240	240	230 or 240	220	236† or 240†
460Y/265	277/480Y	480Y/277	480	480	460 or 480	440	460† or 480†
460	277/480Y	480Y/277	480	480	460 or 480	440	460† or 480†
575	346/600Y	600Y/346 or 600	600	600	575 or 600	550	
Three-Phase Medium-Voltage Systems							
2,400	1,388/2,400Y	2,400Y/1,388 or 2,400	2,400	2,400	2,400	2,300	
4,160	2,400/4,160Y	4,160Y/2,400	4,160	4,160	2,400 or 4,160	4,000	
4,800	2,770/4,800Y	4,800Y/2,770 or 4,800	4,800	13,800 or 7,200	2,770 or 4,800	4,600	
6,900	3,980/6,900Y	6,900Y/3,980	6,900	7,200	4,160 or 6,640	6,600	
7,200	3,980/6,900Y	7,200Y/4,160	7,200	13,800 or 7,200	4,160 or 7,200	6,600	
12,000	7,210/12,500Y	12,000Y/6,920	12,000	13,800	7,200 or 12,470	11,000	
7,200/12,470Y	7,210/12,500Y	12,470Y/7,200	12,000	13,800	7,200 or 12,470		
13,200	7,970/13,800Y	13,200Y/7,610	13,200	13,800	7,620 or 13,800	13,200	
13,800	7,970/13,800Y	13,800Y/7,970	13,800	13,800	7,960 or 13,800	13,200	
14,400	8,320/14,400Y	13,800Y/7,970	13,800	14,400	7,960 or 13,800 or 14,400	13,200	

* Line-to-neutral rating.

† Line-to-line rating.

NAME ______________________ LESSON B-1

DATE ______________________ WORKSHEET

ELECTRICAL SYSTEMS

1. From the Information Sheet which shows the types of A.C. distribution 600 volts or less, list one type of customer for each installation.

   (a) Single phase, 2 wire, 115 volts SMALL FRUIT STAND
   (b) Single phase, 3 wire, 115/230 volts RESIDENCE
   (c) Three phase, 4 wire, 120/208 volts STORE OR OFFICE
   (d) Three phase, 4 wire delta, 120/240 volts SMALL MANUFACTURING PLANT
   (e) Three phase, 4 wire wye, 460/265 volts LARGE STORE OF OFFICE
   (f) Three phase, 3 wire delta, 230 or 460 volts LARGE MANUFACTURING PLANT

2. Which of the above types of distribution systems is referred to as "High Leg"? THREE PHASE, 4 WIRE DELTA, 120/240 VOLTS

3. Which phase (or leg) would be labeled as the "High Leg"? PHASE B What is its N. E. Code color coding? ORANGE List the N.E.C. reference. 215-8

4. What color coding is applied to the "Intentionally grounded" conductor of the transformer? WHITE What is the common term for this conductor? NEUTRAL

5. What other three phase, "3 wire delta voltage" is used for large manufacturing plants? 575 VOLTS

6. List two ways to obtain 120 volt power in an installation using a three phase, "3 wire delta" service. (a) TRANSFORMERS or (b) SEPARATE SERVICE

7. The two standard frequencies used in this country are 25 and 60 cycles.

8. Which frequency is the most widely used? 60

9. There are no standard voltages for D. C. equipment. The most common D. C. voltage is 250. Some manufacturers list 125, 250, 600 and 750 volt equipment.

10. List four reasons for providing **separate** circuits for lighting loads and motor loads.

(a) LARGE STARTING CURRENT OF MOTOR MAY CAUSE LIGHTS TO GROW DIM OR BLINK.

(b) OVERLOADS AND SHORT CIRCUITS ARE MORE COMMON IN MOTOR CIRCUITS AND WOULD CAUSE LIGHTS TO GO OUT.

(c) LIGHTING REQUIRES CLOSER VOLTAGE REGULATION THAN MOTOR CIRCUITS.

(d) IT IS GENERALLY MORE ECONOMICAL TO OPERATE MOTORS AT A HIGHER VOLTAGE THAN THAT OF A LIGHTING CIRCUIT.

A. C. INSTRUMENTS AND THEIR USE

DESIRED RESULTS:

1. To review what the apprentice has found out about how current, voltage, and resistance can be measured.
2. To become more familiar with the types of alternating current instruments.

EQUIPMENT:

1. Available measuring instruments of all types.
2. Materials for demonstration "hookups."

INTRODUCTION:

You know that an electric current is the movement of "free electrons" in a conductor. We have learned that an electric current does not begin to flow all by itself; there must be a source of electrical force to move the "free electrons" through the material. We must use instruments to measure the current, voltage, and resistance. Now let us look again at what you have studied and observed concerning the units of measurement and the correct use of the instruments.

PRESENTING THE LESSON:

1. Demonstrate how a lamp current is measured with an ammeter connected in series , how small currents are measured in milliamperes and microamperes, and how these units of current are changed to amperes.

2. Demonstrate meters for measuring voltage that have ranges in microvolts, millivolts, volts and kilovolts. Review of voltage units and the changing of voltage units.

3. Demonstrate the ohmmeter and how it measures resistance. Review the various units of resistance. Review the various units of resistance and their relation to the basic unit--ohm.

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers on the Assignment Sheet and return to the student for correction.

A. C. INSTRUMENTS AND THEIR USE

GENERAL INFORMATION:

1. When using an Ohmmeter, be sure that the circuit is dead.
2. When using a Multi-meter, be sure the Selector Switch is set for what you want to check.
3. Never exceed the Unit of Meter scale. Always start at the highest multiplier and work down.
4. Never connect a Voltmeter in series with a load. It has a high Internal Resistance and will burn up if connected in series.
5. Never connect an Ammeter parallel. It has a low internal resistance.

NAME ____________________ LESSON NO. B-2

DATE ____________________ WORKSHEET

A.C. INSTRUMENTS

1. MATCH: Place the number representing the name of the Instrument in Column B on the line giving the use, Column A.

		Column A	Column B
3	a.	An instrument used to measure VOLTAGE.	1. Ohmmeter
5	b.	An instrument used to measure POWER.	2. Ammeter
2	c.	An instrument used to measure CURRENT.	3. Voltmeter
1	d.	An instrument used to measure RESISTANCE.	4. Megameter
			5. Wattmeter

2. When usign a Voltmeter to test a circuit, how should it be connected?

PARALLEL OR SHUNT

3. Draw a schematic of a circuit showing a LIGHT, POWER SUPPLY, and a SWITCH. Show the Voltmeter connection to measure the "Drop" across the LIGHT.

AMER. ELEC.-HANDBOOK (A.E.H.)
PP 1-60 FIGURE 69

4. (a) How should an AMMETER be connected in the circuit to be tested?
SERIES A.E.H. PP 1-60

(b) Draw a schematic of a circuit using the same equipment in Question Number 3 and show how the AMMETER should be connected.

A.E.H. PP 1-60 FIGURE 69

5. Give one main purpose of a "megger" or megameter.

CHECK CONDUCTOR INSULATION RESISTANCE. (HIGH RESISTANCE)

A.E.H. PP 1-64 #181

6. (a) What is a MULTI-RANGE AMMETER? BE 1-81 (BASIC ELECTRICITY)

(b) What is a MULTI-RANGE VOLTMETER? BE 1-94

7. Mark T for TRUE and F for FALSE on the line in front of the statement. Give reference proof for your answer on line at the end of each statement.

TRUE a. When using the ohmmeter the cirucit should be dead.
Reason or Ref. BE 1-108

FALSE b. Connect an ammeter parallel in the circuit.
Reason or Ref. SEC 170

FALSE c. Use a voltmeter to measure the resistance of a circuit.
Reason or Ref. SEC 170

TRUE d. When the resistance of a load is given and you have a voltmeter to measure the "Voltage Drop," the current can be found without using an ammeter.
Reason or Ref. OHMS LAW

8. What is a multi-meter? AN INSTRUMENT USED TO CHECK VOLTAGE, CURRENT, AND OHMS USING ONE METER MOVEMENT, AND SELECTOR SWITCH.

9. Explain the "Bell" or "Buzzer" method for location and identifying conductors. PAGE 1-73 SEC. 201 A.E.H.

10. List 5 pieces of Test Equipment in general use.

(a) MULTI-METER
(b) TONG-TEST AMMETER
(c) TEST LAMP
(d) NEON LAMP TESTER
(e) VOLTAGE TESTER
(BELL OR BUZZER)

PRINCIPLES AND TYPES OF TRANSFORMERS

DESIRED RESULTS:

1. To attain an understanding of how the voltage of a source of supply (primary coil) can be used to induce a current in another coil (secondary).

2. To acquaint the students with a few of the many types of transformers.

MATERIALS, EQUIPMENT, AND SUPPLIES:

1. Induction coil
2. Transformers (50 and 100 turn coils)
3. Bar magnet
4. Several small transformers or mock-ups

INTRODUCTION:

The electrical principles set forth in this lesson apply specifically to transformers and indirectly to motors and electronic circuits. Discussion of the operating principles and simple demonstrations of the transformer action are necessary if a thorough understanding of this important device is to be acquired.

It will help the class to point out some specific local applications of each common type of transformer. Show them as many samples of transformers as you have available.

The student should read all the material listed in the references for this lesson and learn how to find this information in the future. The questions are selected to require him to read about the more common aspects of this subject.

PRESENTING THE LESSON:

A. When A.C. flows through a coil, E.M.F. is induced in the coil or an alternating magnetic field is generated around the coil.

   1. E.M.F. is induced in a coil and is called self induction when:

      a. The coil is moved through a magnetic field.
      b. The field is moved through the coil.
      c. The circuit of the electromagnet supplying the magnetic field is opened and closed.

2. Another way is to vary the magnetic flux of the core in a coil.

3. Use a bar magnet to vary induced flux.

4. Explain other uses of induction coils - as telephone circuits, "neon" signs, step-up voltage supply.

B. The E.M.F. generated in the second coil is called the "E.M.F. of Mutual Induction," known as transformer action. Both induction coils and transformers operate by the principle of mutual induction. Point out that:

1. The "induction" coil is really a kind of transformer or voltage changer.

2. A transformer has a primary and a secondary wound on a core of magnetic material.

3. The secondary of an induction coil always has more turns than the primary.

4. A transformer secondary may have more or fewer turns than the primary, depending on whether the voltage is to be increased or decreased.

5. An induction coil has an open core. (The core ends do not form a complete magnetic path.)

6. A transformer has a closed core. (The core forms a complete magnetic path.)

7. Transformers may be used to decrease as well as increase voltage by the mutual induction of their windings.

C. Two kinds of transformers are the step-up and the step-down. Point out that:

1. Both have a primary and a secondary winding.

2. The step-up transformer has more turns of wire in its secondary than in its primary winding, thus a higher voltage is produced in the secondary.

3. A step-down transformer has fewer turns in the secondary than the primary, thus a lower voltage is produced in the secondary. Examples, a pole transformer, a bell transformer, or a toy transformer.

NOTE: It should be explained that "Iron and Copper" losses in transformers (as known in the Electrical Trade) is called Hysteresis. In magnetic material, as iron, a lagging in the values of resulting magnetization is due to a changing magnetizing force. These losses, expressed in watts, are expended as heat and perform no useful work.

APPLICATION:

Have the students work and hand in assignment sheet for checking in Class. Give individual help where needed.

CHECKING AND FOLLOW-UP:

Check assignment sheets against the answer sheets and return to learner for correction and placing in his workbook.

D. The voltage output of a transformer depends on ratio of primary to secondary coil turns. Point out that:

1. The voltage of the secondary of a transformer has the same ratio to the primary voltage as the number of secondary turns has to the number of primary turns. Stated as an equation:

$$\frac{\text{Secondary voltage}}{\text{Primary voltage}} = \frac{\text{Secondary turns}}{\text{Primary turns}}$$

2. Demonstrate this equation in proportion by working several problems on the chalkboard.

E. A current that flows in one direction and then in another is called an alternating current.

1. A transformer ordinarily has an alternating current flow through its primary and always has an alternating current induced in its secondary.

F. Demonstrate the following experiments:

1. Induction coil.

2. Bar magnet to vary induced flux.

3. Make an experimental transformer or use demonstration model or mock-up.

4. Exchanging coils affects secondary voltage.

DISCUSS:

1. The efficiency of a transformer.
2. The service conditions under which a transformer should be able to carry its rated load.
3. Classes of transformers.
4. Methods of cooling.
5. Methods of mounting.

INFORMATION SHEET LESSON B-3

PRINCIPLES AND TYPES OF TRANSFORMERS

The basic theory of transformers will be found in your reference texts along with appropriate illustrations and schematic drawings. These lessons should help you to understand more about the principles of operation, the construction and the installation of the transformers in common use. Be sure to study thoroughly the assigned references found in the American Electrician's Handbook, and also, the other references.

This lesson should help you to understand the electrical principles as they apply to transformers. This knowledge will in turn help you to become a valuable mechanic on the job when there are transformers to be installed.

You will study how the voltage of a source of supply (primary coil) can be used to induce a current into another coil (secondary). This is accomplished by means of mechanical movement through the electromagnetic field or the use of alternating current. Thus the transformer is an inductive device used in alternating current distribution and changes the voltage to higher or lower amounts where needed. As you have learned, a current that flows in one direction and then in another (reversing) is called an alternating current. A transformer ordinarily has an alternating current flow through its primary coil and always has an alternating current induced in its secondary coil. It is doubtful if there would be an electrical industry, if the transformer principle had not been discovered and developed.

The lesson concerns itself with some of the many types of transformers. Transformers are designed for many different uses and frequencies. The type of transformer you will be most concerned with is the power supply transformer. While there are many types you probably will never see on the job, the types studied here are very common and should be familiar to every electrician.

NAME ______________________ LESSON B-3

DATE ______________________ WORKSHEET

PRINCIPLES AND TYPES OF TRANSFORMERS

1. A TRANSFORMER is a device for changing ELECTRICAL energy from one potential to another.

2. What are the two windings of a transformer called?

   a. PRIMARY b. SECONDARY

3. In transformers the primary winding is connected to the LOAD side and the secondary winding is connected to the LINE side. True/False FALSE

4. A step-up transformer delivers energy at a: (B)HIGHER POTENTIAL

   a. Lower Potential c. Upstairs

   b. Higher Potential d. Same Potential

5. List three types of losses in a transformer:

   a. EDDY CURRENT b. * COPPER c. * IRON

*THESE LOSSES EXPRESSED IN WATTS ARE HEAT LOSSES AND PERFORM NO USEFUL WORK.

6. What type of transformer delivers voltage at a lower potential than it receives? STEP DOWN

7. Basic construction of a transformer consist of the following:

   a. PRIMARY WINDINGS b. SECONDARY WINDINGS

   c. CORE

8. Transformers are rated in: (A) KVA

   a. KVA b. TVA c. KWH d. Amps

9. Describe the principle operation of a transformer.

   INDUCED VOLTAGE BY A CHANGING CURRENT

10. The regulation of a transformer is the amount the voltage varies with changing load. True/False TRUE

11. In general the power input of a transformer equals the power output. True/False TRUE

12. What is the correct formula for transformer efficiency ratio? (A)

a. $\frac{\text{output}}{\text{output + copper \& iron losses}}$

b. $\frac{\text{output}}{\text{input + copper \& iron losses}}$

c. $\frac{\text{input}}{\text{output}}$

d. $\frac{\text{output}}{\text{output - copper \& iron losses}}$

13. List six main classifications of transformers:

a. AUTOTRANSFORMER

b. CONSTANT POTENTIAL

c. NETWORK

d. INSTRUMENT

e. CURRENT

f. CONTROL

14. A varying potential transformer is designed to vary the secondary voltage with load on a constant potential supply.
True/False TRUE

15. Which of the following formula is correct for transformer ratio between voltage, current and turns? (C)

a. $\frac{Ep}{Es} = \frac{Ip}{Is} = \frac{Tp}{Ts}$

b. $\frac{Es}{Ep} = \frac{Tp}{Ts} = \frac{Ip}{Is}$

c. $\frac{Ep}{Es} = \frac{Tp}{Ts} = \frac{Is}{Ip}$

16. The power formula for single phase is: (A)

a. $P = EI$ b. $P = \frac{E}{I}$ c. $P = \frac{I}{E}$ d. $P = E + I$

17. Find the ratio of a transformer having a 600 volt primary and a 120 volt secondary.

$\frac{600}{120} = \frac{5}{1}$ OR 5:1

18. Find secondary amps of a transformer having 5 amps primary, primary volts 600, and secondary volts 120.

$\frac{Ep}{Es} = \frac{Is}{Ip}$ $\frac{600}{120} = \frac{Is}{5}$ $Is = 25$ AMPS

19. Find the primary amps of a transformer having secondary amps 40, primary volts 440, secondary volts 220.

$\frac{Ep}{Es} = \frac{Is}{Ip}$ $\frac{440}{220} = \frac{40}{Ip}$ $Ip = 20$ AMPS

20. Find the primary volts of a transformer having secondary volts 120, primary amps 5, and secondary amps 25.

$\frac{E_p}{E_s} = \frac{I_s}{I_p}$ $\frac{E_P}{120} = \frac{25}{5}$ $E_P =$ 600 VOLTS

21. Find the secondary volts of a transformer having primary volts 13,800, primary amps 4, and secondary amps 92.

$\frac{E_p}{E_s} = \frac{I_s}{I_p}$ $\frac{13,800}{E_S} = \frac{92}{4}$ $E_S =$ 600 VOLTS

22. Find the primary turns of a transformer having 100 turns secondary, 440 volts primary, 220 volts secondary, and 2 amps primary.

$\frac{E_p}{E_s} = \frac{T_p}{T_s} = \frac{I_s}{I_p}$ $\frac{440}{220} = \frac{T_P}{100}$ $T_P = 200$

23. Find the primary and secondary watts that a transformer draws from the line with primary turns 100, secondary turns 20, primary volts 120, and secondary amps 5. Assume 100% efficiency:

$\frac{E_p}{E_s} = \frac{T_p}{T_s} = \frac{I_s}{I_p}$ $\frac{100}{20} = \frac{I_S}{5}$ $I_P = 1$

$P = EI$ $\frac{100}{20} = \frac{120}{E_S} = E_S = 24$ VOLTS

PRIMARY WATTS = P = 120 x 1 = 120 WATTS
SECONDARY WATTS = P = 24 x 5 = 120 WATTS

24. Find the efficiency of a transformer with 200 watts primary and 190 watts secondary.

$\frac{\text{Output}}{\text{Input}} = \frac{190}{200} = 95\%$ EFFICIENCY

25. The input of a transformer is the same as the output plus copper and iron losses. True/False TRUE

26. Find the percent regulation of a transformer which reads 575 volts secondary at no load and 550 volts secondary at full load.

$$\text{Percent Reg.} = \frac{\text{No load sec.} - \text{full load sec.}}{\text{Full load sec.}}$$

$$\% = \frac{575 - 550}{550} = \frac{25}{550} = 4.5\%$$

SINGLE PHASE TRANSFORMERS

DESIRED RESULTS:

To learn the basic facts needed to hook up a single phase transformer.

MATERIALS AND EQUIPMENT:

1. Open type transformer
2. Chalkboard

INTRODUCTION:

Transformer connections seem to be a complicated subject to many electricians. The student must learn the basic facts of the simple single-phase connections if he expects to understand the three-phase connections later.

PRESENTING THE LESSON:

The electrician will not hook up a transformer every day and he should not ask someone else to show him how to do the work.

Demonstrate on the chalkboard and on the model transformer how to make the connections. Have the students draw transformer connections on the board and on notebook paper without help of the book.

APPLICATION:

Have the students complete the questions on the assignment sheet in class. Give individual help where needed.

CHECKING AND FOLLOW-UP:

Check the assignment sheets against the answer sheet and return to the students for placing in their notebooks.

TRANSFORMER DEFINITIONS AND TERMS

A. Air-cooled--A transformer which uses air as the cooling medium. This may be natural draft cooling by convection, or forced air with the use of fans.

Ambient Noise Level--The existing or inherent sound level of the area surrounding a transformer installation measured in decibels.

Ambient Temperature--The inherent or existing temperature of the atmosphere surrounding the transformer installation into which the heat losses of the transformer are dissipated.

ANSI--American National Standards Institute is the recognized body which specifies the standards on transformers. ANSI C 89.1 and C 57.12 are the standards most often used.

Askarel-- Non-flammable liquid with high dielectric strength. Primarily used for cooling and insulating liquid filled transformers installed indoors.

Auto-Transformer--A transformer which has only one winding per phase, part of which is common to both primary and secondary circuits.

B. BIL--Basic Insulation Level is a reference insulation level expressed as the maximum crest voltage that the insulation will withstand when a 1.5 x 40 microsecond pulse is applied. This is a measure of the ability of the insulation to withstand very high voltage surges.

Buck Boost--An insulating transformer which has low voltage secondary windings (usually 12/24 or 16/32 V.) and is normally connected as an auto-transformer for raising or lowering the supply voltage in small amounts.

C. Center Tap--A reduced capacity tap at the mid point in a winding.

Certified Test--Actual production or laboratory tests which certify values as having been taken on a specific item, on a specific order.

Compensated Transformer--A transformer with a turns ratio which provides a higher than rated voltage at no load and rated voltage at rated load.

Continuous Rating--Refers to the load that a transformer can handle indefinitely without exceeding the specified temperature rise.

Control Transformer--A transformer which is designed for good voltage regulation characteristics when low power factor, large in-rush currents are drawn (5 to 15 times normal).

Conductor Losses--Losses caused by the resistance of the transformer winding and usually measured at 25, 50, 75, and 100 percent of load.

Core Loss--Losses caused by a magnetization of the core and its resistance to magnetic flux.

Current Transformer--A transformer designed to have its primary winding connected in series with the circuit and used for transforming current to a value suitable for measurement or control.

D. Decibel--(DB) The standard unit used in the measurement of sound intensity. See discussion on sound levels in the Application and Engineering Data section.

Delta--(Δ) A standard three phase connection in which each phase winding is connected in series to form a closed loop.

Delta Wye--(Δ-Y) The term used when indicating the method of connection for both the primary and secondary windings of a three phase transformer bank.

Dielectric Tests--A series of tests conducted at much higher than rated nameplate voltage to determine the effectiveness of insulating materials and electrical clearances.

Distribution Transformer--Any transformer rated between 3 and 500 KVA, inclusive, with a primary voltage of 601 volts or greater.

Dry Type Transformer--A dry type transformer is one which does not employ a liquid as a cooling or insulating medium.

Dual Winding--A winding that consists of two separate windings which can be connected in series to handle a specified voltage and KVA, or in parallel to handle the same KVA at one-half the series connected voltage.

E. Electrostatic Shield--A grounded conductor sheet placed between the primary and secondary windings to prevent the transfer of radiated electrical energy or interference from one circuit to the other.

Exciting Current--The current which maintains the excitation of a transformer--the current that flows in the primary when the load is disconnected. Usually expressed in percent of the rated current of the winding.

Extended Winding--A winding with additional turns to provide application of a higher voltage. This effectively changes the turns ratio of the transformer when the extended winding is employed in the circuit. Example: FCAN taps.

F. **FCAN**--Full capacity above normal taps. The designation used to indicate that a transformer will deliver rated KVA when connected to a voltage source which is higher than rated voltage.

FCBN--Full capacity below normal taps. Same as FCAN except that the taps are below rated voltage.

Fan Cooled--A means of accelerating heat dissipation to lower the temperature rise of the transformer. This has the effect of increasing the transformer rating.

Filter Press--A device for absorbing moisture from oil or askarel. Liquid is force-circulated through absorbent pads.

Flexible Connector--A pliable conductor, conduit or wire-way designed to compensate for thermal expansion and contraction, or reduce the transmission of objectionable noise.

Frequency--The number of times an AC voltage will alternate from positive to negative and back again within a specified period of time, usually expressed in cycles per second and identified as Hz as in 60 Hz.

Full Capacity Tap--Tap that is designed to deliver the rated capacity of the transformer.

G. **Grounding Transformer**--A special three phase auto-transformer used to establish a stable neutral point on a three wire delta system (See Zig-Zag Transformer).

H. **Hertz (Hz)**--Expression of AC frequency in cycles per second. (Example--60 Hz)

High Reactance Transformer--A design which has high leakage reactance to limit output current to a designated value in the event of a fault. Also called Energy Limiting transformer.

Hi Pot--A standard dielectric test to check insulating materials and clearances between windings and between winding and ground.

I. Impulse Tests--The test employed to determine basic Insulation level (BIL).

Impedance--The vector sum of resistance and reactance which limits the current flow in an AC circuit.

Induced Potential Test--A standard dielectric test which verifies the ability of insulating materials and electrical clearances between turns and between layers of a transformer winding.

Inrush Current--An abnormally high current which is occasionally drawn when a transformer is first energized, due to residual flux in the core.

Instrument Transformer--A transformer designed to transform the conditions of current or voltage and phase position in the primary, with a specified accuracy in the secondary circuit.

Insulating Material--Organic or inorganic substances which prevent or greatly reduce the current flow between live parts or between live parts and ground.

Insulating Transformer--One in which the primary winding is insulated from the secondary winding.

Interleaving--A method of winding where the primary and secondary are wound in sections, with a section of the primary between two sections of the secondary and vice versa. This technique is used to reduce the leakage reactance of the transformer when desirable to do so.

Isolating Transformer--A transformer which insulates the primary circuit from secondary circuit as with an insulating transformer, but frequently with no voltage change.

J. Jack Pads--Structural member at bottom of transformer tank to accomodate Hydraulic Jacks which lift unit onto rollers for moving into position.

K. KVA--Kilovolt Ampere rating designates the output which a transformer can deliver at rated voltage and frequency without exceeding a specified temperature rise.

L. Liquid Filled Transformer--One in which the core and coil structure is immersed in a liquid, usually oil, which acts as both a cooling and insulating medium.

Liquid Level Gauge--Indicates level of liquid within tank. Normal level indicated at 25°C. Operates by magnetic coupling.

Load--The KVA or VA requirement which the transformer must supply.

Load Center Unit Substation Transformer--A transformer that is mechanically and electrically connected to and coordinated in design with switchgear or motor control assemblies.

Load Losses--Those losses which are the result of a current flowing to the load. Load losses would include all losses incurred above and beyond the no-load losses.

M. Multiple Winding--A winding which consists of two or more sections that can be paralleled for a specific mode of operation.

N. NEMA Standard--Any standard recommended by the National Electrical Manufacturers Association.

Network Transformer--A transformer which is electrically and mechanically connected to and coordinated in design with switchgear or motor control assemblies for use on a utility network power system.

No-Load Losses--The losses incurred when a transformer is excited but without a load connected to the secondary. These include core loss, dielectric loss, and exciting current I^2R loss.

P. Parallel Operation--Transformers or transformer windings may be connected in parallel provided that the electrical characteristics are suitable for such operation.

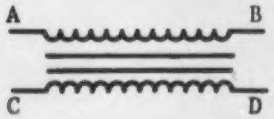
Percent IR--(% IR)--Percent Resistance--The voltage drop due to conductor resistance at rated current expressed in percent of rated voltage.

Percent IX--(% IX)--Percent Reactance--The voltage drop due to reactance at rated current expressed in percent of rated voltage.

Percent IZ--(% IZ)--Percent Impedance--The voltage drop due to impedance at rated current expressed in percent of rated voltage.

Phase--Classification of an AC circuit, usually single phase, two wire or three wire; two phase, three wire or four wire; or three phase, three wire or four wire.

Polarity--A designation of the relative instantaneous direction of the current in a secondary lead as compared with a primary lead. The two leads are said to be of the same polarity when, at any instant, the currents in the two leads are flowing in the same direction as if the leads were a single piece of wire. The polarity of a single phase transformer is classed as either additive or substractive:



With leads A and C connected together and a voltage applied between A and B, the polarity is said to be additive if the voltage between B and D is greater than the applied voltage. If the voltage between B and D is less than that applied, the polarity is said to be subtractive.

Polyphase--More than one phase.

Potential Transformer--A transformer that is designed to have its primary winding connected parallel with a circuit and used for transforming voltage to a value suitable for measurement or control.

Power Factor--The ratio of watts to volt amperes in a circuit. Expressed as watts/VA.

Power Transformer--Any transformer rated above 500 KVA at a voltage of 601 volts or above.

Pressure Relief Device--Used to relieve excessive pressure inside tank. Generally operates at 7 1/2 psi. Self-resealing with target indicator to show operation. Alarm contacts are optional.

Pressure Vacuum Bleeder Valve--Automatic valve which opens and closes to maintain internal pressure within predetermined limits.

Pressure Vacuum Gauge--Measures pressure inside tank, both above and below atmospheric.

Primary Winding--A winding connected to the voltage source or input.

R. Radiators--Tank extensions used to assist cooling the oil and transformer. Panel type is generally used for better efficiency and appearance.

Rating--This refers to the characteristics such as volt ampere capacity, voltages, frequency, and temperature rise for which a transformer is designed.

Ratio--A reference to either the turns ratio or to the voltage ratio of the transformer.

Reactance--A component of impedance produced by either inductance or capacitance in an AC circuit.

Reactor--A device generally a single winding on an air core or an iron core which produces a specific amount of inductive reactance for which it is designed.

Rectifier Transformer--A transformer designed to supply the AC input to a rectifier to the value necessary to obtain the desired DC output and have the ability to withstand the unusual heating effects caused by rectifier commutation or ripple.

Reduced Capacity Taps--Tap that is not designed to deliver the rated capacity of the transformer.

Regulation--The percent change in output voltage from full load to no load.

S. Scott Connection--A transformer connection usually used to get a two phase output from the secondary of a transformer with a three phase input to the primary, or vice versa. It can also be used to provide 3 phase to 3 phase transformation.

Secondary Winding--The transformer winding connected to the load or output side.

Sealed Dry Type Transformer--Dry type core and coils in a tank containing an inert gas such as nitrogen or freon under slight pressure.

Series/Multiple--A winding consisting of several sections which can be connected for series or parallel operation.

Star Connection--Same as the wye connection.

Step Down Transformer--One in which the high voltage winding is connected to the input or power source and the low voltage winding to the output or load.

Step Up Transformer--A transformer in which the low voltage winding is connected to the power source or input and the high voltage winding is connected to the output or load.

Sudden Pressure Relay--Pressure switch device which operates instantaneously to disconnect transformer from line. Sudden pressure is usually caused by internal transformer fault.

T. T-Connection--A Scott connected three phase transformer utilizing two primary and two secondary coils called the main and teaser coils.

Tap--A connection between transformer winding which has the effect of changing the nominal voltage ratio of the transformer.

Temperature Indicator--Measures temperature of top oil within tank. Has provision for resetting maximum temperature indication.

Temperature Rise--The temperature increase over ambient due to load. This is measured as either average rise by resistance or as hot-spot.

Thermal Overload Relay (TRO-2)--Allows loading transformer to full thermal capacity by analyzing loads, temperatures, and transformer time constant. Operates contacts for alarm and/or forced air cooling fans.

Transformer--A transformer is a static electrical device which by electro-magnetic induction transfers electrical energy from one circuit to another circuit, usually with changed values of voltage and current.

Turns Ratio--See Ratio.

V. Volt Amperes--The current flowing in a circuit multiplied by the voltage of that circuit. An expression of the output rating of a transformer.

Voltage Ratio--See Ratio.

Voltage Regulation--See Regulation.

W. Wye Connection--A three phase connection in which similar ends of each phase winding are connected together at a common point which forms the electrical neutral and is often grounded.

Z. Zig-Zag Transformer--Commonly used term for a grounding transformer.

Wiring Diagrams

Single Phase

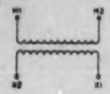


DIAGRAM 1 NO TAPS

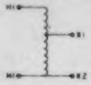


DIAGRAM 2 NO TAPS

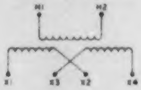

H1
H2
X1
X3
X2
X4

DIAGRAM 3 NO TAPS

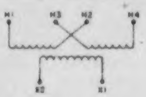

H1
H3
H2
H4
X2
X1

DIAGRAM 4 NO TAPS

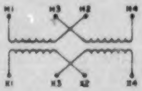

H1
H3
H2
H4
X1
X3
X2
X4

DIAGRAM 5 NO TAPS

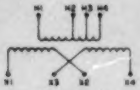

H1
H2
H3
H4
X1
X3
X2
X4

DIAGRAM 6 2-5% FCBN TAPS

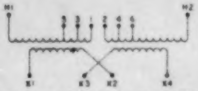

H1
H2
X1
X3
X2
X4

DIAGRAM 7 2-2½% FCAN 2-2½% FCBN TAPS OR 4-2½% FCBN TAPS

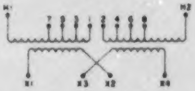

H1
H2
X1
X3
X2
X4

DIAGRAM 8 2-2½% FCAN 4-2½% FCBN TAPS

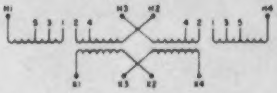

H1
H3
H2
H4
X1
X3
X2
X4

DIAGRAM 9 2-2½% FCAN 4-2½% FCBN TAPS

Three Phase "T" Connected

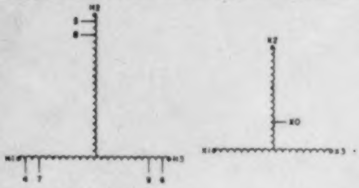

H2
5
8
X2
X0
H1
H3
X1
X3
4
7
9
6

DIAGRAM 10 2-5% FCBN TAPS

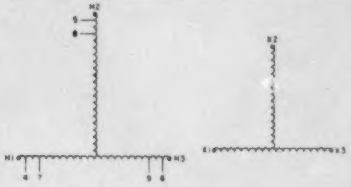

H2
5
8
X2
H1
H3
X1
X3
4
7
9
6

DIAGRAM 11 2-5% FCBN TAPS

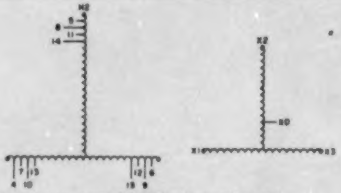

H2
5
8
11
14
X2
X0
X1
X3
7
13
4
10
12
6
15
9

DIAGRAM 12 2-2½% FCAN 2-2½% FCBN TAPS

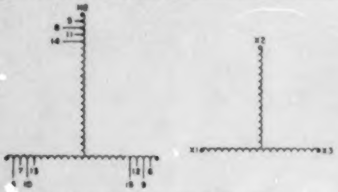

H2
5
8
11
14
X2
X1
X3
7
13
4
10
12
6
15
9

DIAGRAM 13 2-2½% FCAN 2-2½% FCBN TAPS

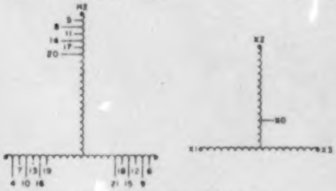

H2
5
8
11
14
17
20
X2
X0
X1
X3
7
13
19
4
10
16
18
12
6
21
15
9

DIAGRAM 14 2-2½% FCAN 4-2½% FCBN TAPS

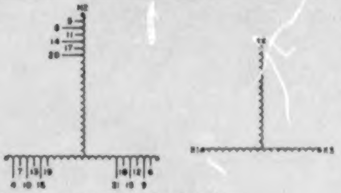

H2
5
8
11
14
17
20
X2
X1
X3
7
13
19
4
10
16
18
12
6
21
15
9

DIAGRAM 15 2-2½% FCAN 4-2½% FCBN

Three Phase

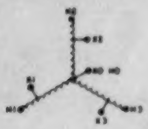


DIAGRAM 16 NO TAPS

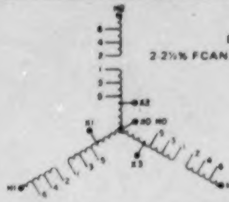


DIAGRAM 17 2-2½% FCAN 4-2½% FCBN

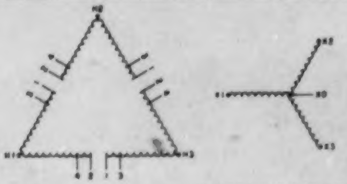


DIAGRAM 18 2-5% FCBN

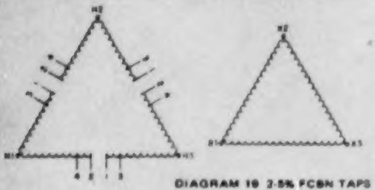


DIAGRAM 19 2-5% FCBN TAPS

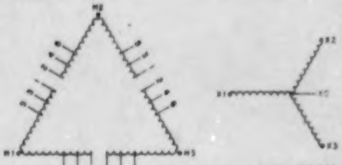


DIAGRAM 20 2-2½% FCAN 2-2½% FCBN TAPS

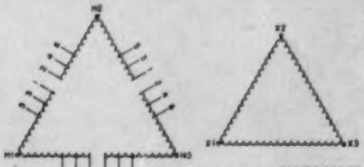


DIAGRAM 21 2-2½% FCAN 2-2½% FCBN TAPS

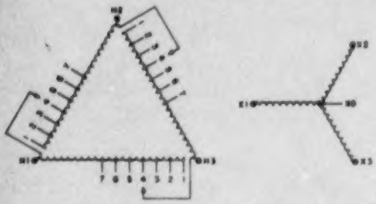


DIAGRAM 22 2-2½% FCAN 4-2½% FCBN TAPS

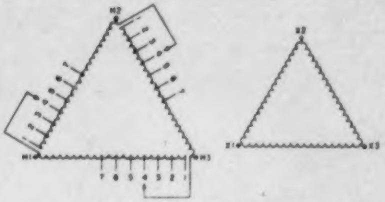


DIAGRAM 23 2-2½% FCAN 4-2½% FCBN TAPS

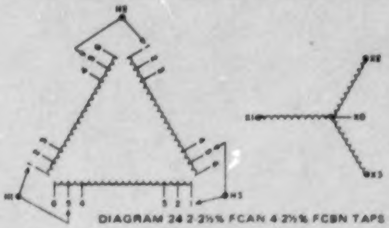


DIAGRAM 24 2-2½% FCAN 4-2½% FCBN TAPS

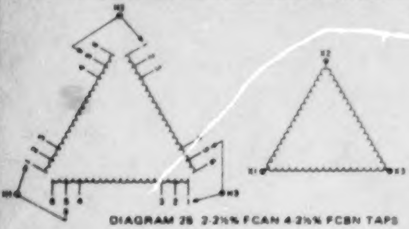


DIAGRAM 25 2-2½% FCAN 4-2½% FCBN TAPS

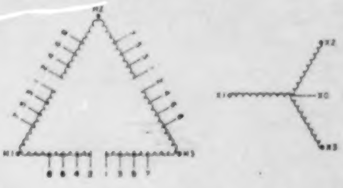


DIAGRAM 26 2-2½% FCAN 4-2½% FCBN TAPS

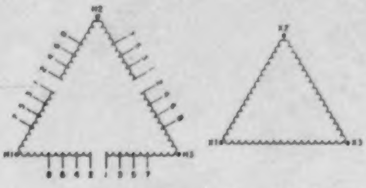


DIAGRAM 27 2-2½% FCAN 4-2½% FCBN TAPS

NAMEPLATE DESIGNATION OF VOLTAGE RATINGS OF WINDINGS
Reference NEMA Standard TR-27 & ANSI C 57.12

TABLE I – SINGLE PHASE TRANSFORMERS

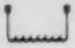
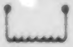
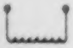
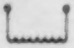
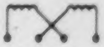
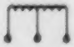
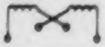
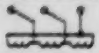
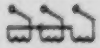
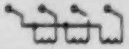
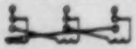
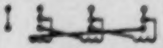
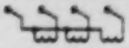
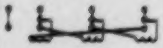
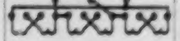
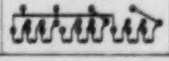
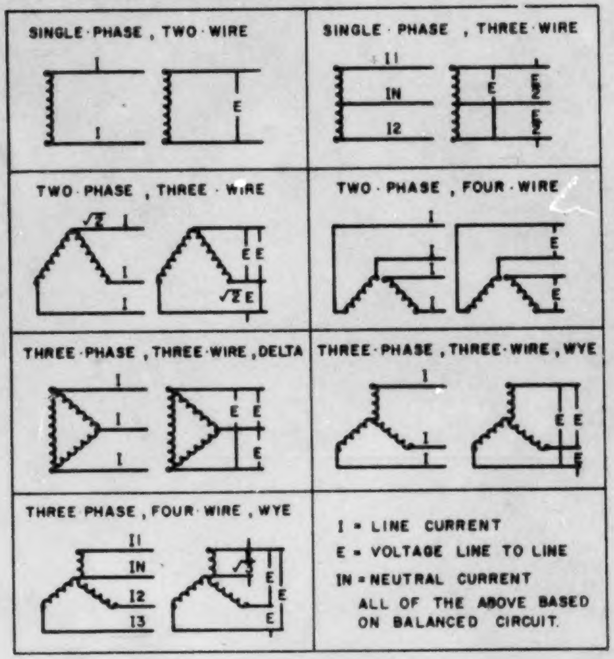
Nomenclature	Typical Examples Nameplate Marking	Typical Winding Diagram	Condensed Usage Guide
E	34500		Indicates a winding for Δ connection on an E volt system.
E/E$_1$Y	2400/4160Y		Indicates a winding for Δ connection on an E volt system or Y connection on an E$_1$ volt system.
E/E$_1$GrdY	38700/67000GrdY		Indicates a winding with reduced insulation for Y connection on an E$_1$ volt system with the transformer neutral effectively grounded or for Δ connection on an E volt system.
E$_1$GrdY/E	12470GrdY/7200		Indicates a winding with reduced insulation at the neutral end. The neutral end may be connected directly to the tank for connection single phase or in Y on an E$_1$ volt system with the neutral end of the winding effectively grounded.
E/2E	120/240, 240/480		Indicates a winding for multiple, series, or three-wire service.
2E/E	240/120		Indicates a winding for 2E volts, two-wire full kva, or for 2E/E volts three-wire service with one-half kva available from mid-point to each outside terminal.
V×V$_1$	240×480 or 2400/4160Y×4800/8320Y		Indicates a winding for multiple or series operation only. (Not for three-wire service.)

TABLE II – THREE PHASE TRANSFORMERS

Nomenclature	Typical Examples Nameplate Marking	Typical Winding Diagram	Condensed Usage Guide
E	240		Indicates a winding permanently Δ (Delta) connected.
EY	4160Y		Indicates a winding permanently Y connected with the neutral isolated.
E$_1$Y/E	4160Y/2400		Indicates a winding permanently Y connected with fully insulated neutral available.
E/E$_1$Y	2400/4160Y		Indicates a winding for connection E volts Δ or E$_1$Y volts with the neutral isolated.
E/E$_1$Y/E	2400/4160Y/2400		Indicates a winding for connection E volts Δ or E$_1$Y volts with a fully insulated neutral available.
E$_1$GrdY/E	67000GrdY/38700		Indicates a winding having reduced insulation and permanently Y connected with the transformer neutral grounded.
E/E$_1$GrdY/E	38700/67000GrdY/38700		Indicates a winding having reduced insulation for Y connection on an E$_1$ volt system with the transformer neutral grounded or for Δ connection on an E volt system.
V×V$_1$	7200×14400		Indicates a permanently Δ connected winding for multiple or series operation.
	4160Y/2400×12470Y/7200		Indicates a permanently Y connected winding for multiple or series operation.

Key: $E_1 = \sqrt{3} \times E$

SYSTEM WIRING DIAGRAMS


SINGLE-PHASE, TWO-WIRE
I
I
E
SINGLE-PHASE, THREE-WIRE
I1
IN
I2
E
E/2
E/2
TWO-PHASE, THREE-WIRE
√2 I
I
I
E E
√2 E
TWO-PHASE, FOUR-WIRE
I
I
I
I
E
E
THREE-PHASE, THREE-WIRE, DELTA
I
I
I
E E
E
THREE-PHASE, THREE-WIRE, WYE
I
I
I
E E
E
THREE PHASE, FOUR-WIRE, WYE
I1
IN
I2
I3
E/√3
E
E
E
I = LINE CURRENT
E = VOLTAGE LINE TO LINE
IN = NEUTRAL CURRENT
ALL OF THE ABOVE BASED ON BALANCED CIRCUIT.

TRANSFORMER TAP SELECTOR CHART

Proper	Nominal Transformer Input Voltage Rating											
Tap	**120**	**240**	**480**	**600**	**2400**	**4160**	**4800**	**7200**	**12470**	**13200**	**13800**	**14400**
+5%	126	252	504	630	2520	4368	5040	7560	13094	13860	14490	15120
+2½%	123	246	492	615	2460	4264	4920	7380	12782	13530	14145	14760
Rated	120	240	480	600	2400	4160	4800	7200	12470	13200	13800	14400
−2½%	117	234	468	585	2340	4056	4680	7020	12158	12870	13455	14040
−5%	114	228	456	570	2280	3952	4560	6840	11846	12540	13110	13680
−7½%	111	222	444	555	2220	3848	4440	6660	11535	12210	12765	13320
−10%	108	216	432	540	2160	3744	4320	6480	11223	11880	12420	12960

TO PROPERLY USE CHART: Read actual incoming supply voltage, then find nominal voltage rating, under that rating find closest value to actual reading taken, read across to the left to the "Proper Tap" and connect.

THREE PHASE SUPPLY EMPLOYING THREE SINGLE PHASE TRANSFORMERS

FIG. 1

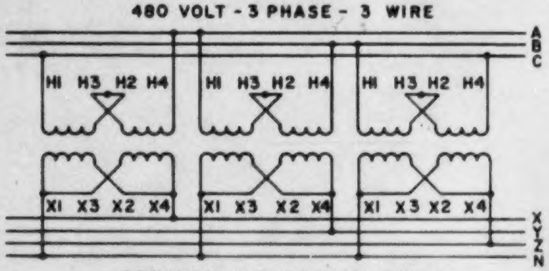
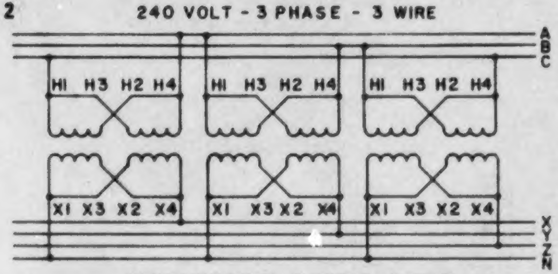

480 VOLT - 3 PHASE - 3 WIRE
A
B
C
HI H3 H2 H4
HI H3 H2 H4
HI H3 H2 H4
XI X3 X2 X4
XI X3 X2 X4
XI X3 X2 X4
X
Y
Z
N
208Y/120 VOLT - 3 PHASE - 4 WIRE

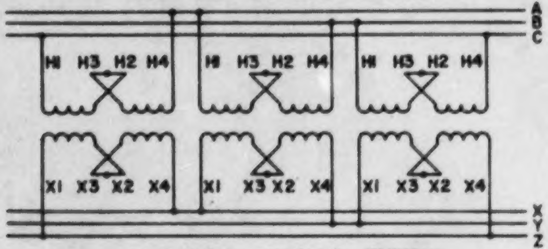
FIG. 2


240 VOLT - 3 PHASE - 3 WIRE
A
B
C
HI H3 H2 H4
HI H3 H2 H4
HI H3 H2 H4
XI X3 X2 X4
XI X3 X2 X4
XI X3 X2 X4
X
Y
Z
N
208Y/120 VOLT - 3 PHASE - 4 WIRE

Three dual wound transformers connected Δ-Y for three phase 480Δ-208Y/120 volts in Figure 1, and 240Δ-208Y/120 volts in Figure 2. Total KVA is the sum of the three.

FIG. 3

480 VOLT - 3 PHASE - 3 WIRE

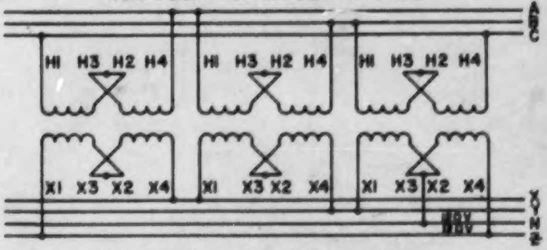

A
B
C
HI H3 H2 H4
HI H3 H2 H4
HI H3 H2 H4
XI X3 X2 X4
XI X3 X2 X4
XI X3 X2 X4
X
Y
Z

240 VOLT - 3 PHASE - 3 WIRE

Three dual wound transformers in a Δ-Δ connection, 480Δ-240Δ volts. Total KVA is the sum of the three units.

FIG. 4

480 VOLT - 3 PHASE - 3 WIRE

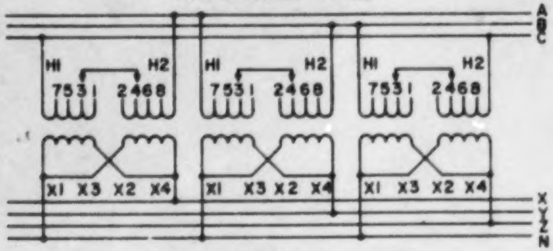

A
B
C
HI H3 H2 H4
HI H3 H2 H4
HI H3 H2 H4
XI X3 X2 X4
XI X3 X2 X4
XI X3 X2 X4
120V
120V
X
Y
N
Z

240 VOLT - 3 PHASE - 3 WIRE
WITH CENTER TAP IN ONE PHASE
FOR 240/120 VOLT - 1 PHASE - 3 WIRE

Fig. 4 is identical to fig. with the additional tap on only one leg of one unit connected for 120 volt single phase supply.

FIG. 5

480 VOLTS WITH 2-2½% FCAN & 4-2½% FCBN TAPS 3 PHASE 3 WIRE

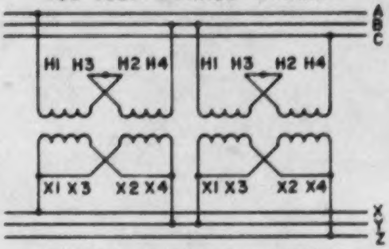

A
B
C
HI H2
7531 2468
HI H2
7531 2468
HI H2
7531 2468
XI X3 X2 X4
XI X3 X2 X4
XI X3 X2 X4
X
Y
Z
N

120 VOLT - 3 PHASE - 3 WIRE

Three single wound primary units connected 480Δ-208Y/120 volts.

FIG. 6

480 VOLT - 3 PHASE - 3 WIRE


A
B
C
HI H3 H2 H4
HI H3 H2 H4
XI X3 X2 X4
XI X3 X2 X4
X
Y
Z

120 VOLT - 3 PHASE - 3 WIRE

Two dual wound primary units in open delta connection. KVA output is 86% of the sum of the two.

TRANSFORMER FULL LOAD CURRENT TABLES

Rated Line Amperes for KVA and Voltages of Single Phase Transformers

Table 1

KVA Rating	120V	208V	240V	277V	480V	600V	2400V	4160V	4800V	7200V	13200V
	AMPERES										
1	8.33	4.81	4.17	3.61	2.08	1.67	–	–	–	–	–
1.5	12.5	7.21	6.25	5.42	3.13	2.50	–	–	–	–	–
2	16.7	9.62	8.33	7.22	4.17	3.33	–	–	–	–	–
3	25.0	14.42	12.5	10.83	6.25	5.00	1.25	.721	.625	.417	.227
5	41.7	24	20.8	18.1	10.4	8.33	2.08	1.2	1.04	.694	.379
7.5	62.5	36.1	31.3	27.1	15.6	12.5	3.13	1.8	1.56	1.04	.568
10	83.3	48.1	41.7	36.1	20.8	16.7	4.17	2.4	2.08	1.39	.758
15	125	72.1	62.5	54.2	31.3	25.0	6.25	3.61	3.13	2.08	1.14
20	167	96.2	83.3	72.2	41.7	33.3	8.33	4.81	4.17	2.78	1.52
25	208	120	104	90.3	52.1	41.7	10.4	6.01	5.21	3.47	1.89
30	250	144	125	108	62.5	50	12.5	7.21	6.25	4.17	2.27
37.5	313	180	155	135	78.0	62.5	15.6	9.01	7.80	5.21	2.84
50	417	240	208	181	104	83.3	20.8	12	10.4	6.94	3.79
75	625	361	313	271	156	125	31.3	18	15.6	10.4	5.68
100	833	481	417	361	208	167	41.7	24	20.8	13.9	7.58
150	1250	721	625	542	313	250	62.5	36.1	31.3	20.8	11.4
167	1392	803	696	603	348	278	69.6	40.1	34.8	23.2	12.7
200	1667	962	833	722	417	333	83.3	48.1	41.7	27.8	15.2
250	2083	1202	1042	903	521	417	104	60.1	52.1	34.7	18.9
333	2775	1601	1388	1202	694	555	139	80	69.4	46.3	25.2
500	4167	2404	2083	1805	1042	833	208	120	104	69.4	37.9

Rated Line Amperes for KVA and Voltages of Three Phase Transformers

Table 2

KVA Rating	208V	240V	480V	600V	2400V	4160V	4800V	13200V	26000V	35000V	46000V
	AMPERES										
3	8.34	7.23	3.61	2.89	.723	.417	.361	.131	–	–	–
6	16.6	14.4	7.2	5.8	1.46	.83	.72	.26	–	–	–
9	25	21.7	10.8	8.67	2.17	1.25	1.08	.394	–	–	–
15	41.7	36.1	18.1	14.5	3.61	2.08	1.81	.657	–	–	–
20	55.6	48.2	24.1	19.3	4.82	2.78	2.41	.876	–	–	–
25	69.5	60.2	30.1	24.1	6.02	3.48	3.01	1.09	–	–	–
30	83.4	72.3	36.1	28.9	7.23	4.17	3.61	1.31	–	–	–
37.5	104	90.3	45.2	36.1	9.03	5.22	4.52	1.64	–	–	–
45	125	108	54.2	43.4	10.8	6.26	5.42	1.97	–	–	–
50	139	120	60.2	48.2	12	6.96	6.02	2.19	–	–	–
60	167	145	72.3	57.8	14.5	8.35	7.23	2.63	–	–	–
75	208	181	90.3	72.3	18.1	10.4	9.03	3.28	–	–	–
100	278	241	120	96.3	24.1	13.9	12	4.38	–	–	–
112.5	313	271	135	108	27.1	15.7	13.5	4.93	–	–	–
150	417	361	181	145	36.1	20.9	18.1	6.57	–	–	–
200	556	482	241	193	48.2	27.8	24.1	8.76	–	–	–
225	625	542	271	217	54.2	31.3	27.1	9.85	–	–	–
300	834	723	361	289	72.3	41.7	36.1	13.1	–	–	–
400	1112	963	482	385	96.3	55.7	48.2	17.5	–	–	–
500	1390	1204	602	482	120	69.6	60.2	21.9	–	–	–
750	2084	1806	903	723	181	104	90.3	32.8	–	–	–
1000	2779	2406	1204	963	241	139	120	43.8	22.2	16.5	12.6
1500	4169	3613	1806	1445	361	208	181	65.7	33.3	24.8	18.8
2000	5558	4817	2408	1927	482	278	241	87.6	44.5	33	25.1

NAME ______________________________ LESSON B-4

DATE ______________________________ WORKSHEET

SINGLE PHASE TRANSFORMERS

1. Match the capital letter on each of the following schematic drawings to the proper transformer description:

D Transformer having single primary winding and dual secondary windings, with secondary connected in series.

A Transformer having dual primary connected in series and dual secondary connected in parallel.

F Transformer having dual primary connected in series and dual secondary connected in series.

E Transformer having single primary and secondary windings.

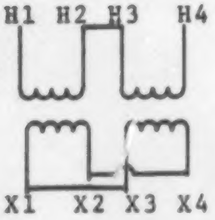
B Transformer connected additive polarity.

G Transformer connected subtractive polarity.

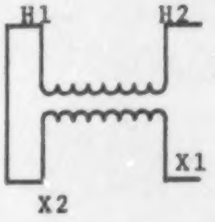
C Autotransformer.

H Transformer having dual primary connected in parallel and single secondary windings.

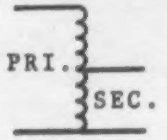
A.


H1
H2
H3
H4
X1
X2
X3
X4

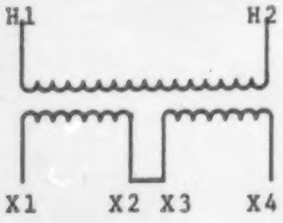
B.



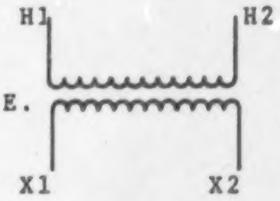
C.



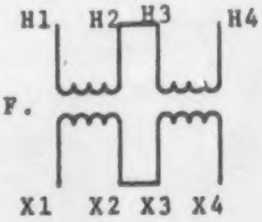
D.


H1
H2
X1
X2
X3
X4

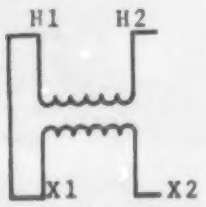
E.



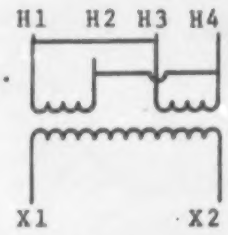
F.


H1
H2
H3
H4
X1
X2
X3
X4

G.



H.


H1
H2
H3
H4
X1
X2

2. The autotransformer is the most efficient and effective means of increasing or decreasing voltage. True/False TRUE

3. Single phase transformers on an unbalanced 3-wire system should be designed in order for each transformer to: (Circle answer.) (D)

   a. be at least 5 KVA each

   b. have two ground wires

   c. be neutral, and black in color

   d. be equal to twice the load on the most heavily loaded of the two side circuit

4. Two phase, four wire systems transformers should be designed for line voltage and line current. True/False TRUE

5. Coils of either a single phase or a three phase transformer may be connected for operating as an autotransformer. True/False TRUE

6. National Electrical Code Article 210-9 covers: (Circle answer.) (B)

   a. Three phase transformer branch circuits

   b. Autotransformer branch circuits permitted

   c. Single phase transformers branch circuits

INSTRUCTOR'S MANUAL LESSON B-5

THREE-PHASE TRANSFORMERS

DESIRED RESULTS:

To acquaint the student with the technical or the theory and practice of three-phase transformer connections.

INTRODUCTION:

This lesson concerns itself with the technical information about transformer connections. The student will need to know the facts learned in this lesson in order to make schematic drawings of actual connections. Have the students pay particular attention to the voltage and current relationships in wye and delta connections. These relationships apply to other devices such as generator and motor coils.

Three-phase transformer connections have become so varied and complicated that it is impossible for a student electrician to become completely familiar with the subject, or to analyze without diagrams many of the problems that arise. However, a basic knowledge and understanding of simple transformer connections is not only essential to the apprentice from a standpoint of know-how, but this knowledge is also necessary for personal safety when he is connecting transformers.

PRESENTING THE LESSON:

There are several basic transformer connections that the apprentice must memorize and be able to recognize at first glance in an actual transformer set-up and in wiring diagrams. These basic connections for three-phase work are delta and wye (Y) for three and four wire systems.

Present the advantages and disadvantages of a three-phase transformer. Discuss the voltage and current on the windings of a delta-delta connected transformer. Discuss the voltage and current on the windings of a wye-wye connected transformer.

In connecting large transformers in parallel, they will operate satisfactory with their low and high-tension windings connected to the same circuits provided they have (1) the same ratio of transformation,(2) the same voltage rating,and (3) approximately the same regulation.

Discuss the advantages of the wye connected primary. Discuss the disadvantages of the open delta transformer connection. Discuss the relative cost of transformer connections.

APPLICATION:

Have the students complete the questions on the assignment sheet.

CHECKING AND FOLLOW-UP:

Correct the answers on the assignment sheet and return to the students. Discuss any questions that need to be clarified.

NAME ______________________________ LESSON B-5

DATE ______________________________ WORKSHEET

THREE-PHASE TRANSFORMERS

1. What three factors make the installation of a three-phase transformer more advantageous than a bank of single phase transformers operating as a unit?

   a. LOWER COST

   b. HIGHER EFFICIENCY

   c. LESS SPACE REQUIRED TO INSTALL

   (ALTERNATE ANSWER)

   (D) LOADS CAN BE BALANCED BETTER

2. The voltage on the windings of a delta-delta connected transformer is equal to the LINE voltage.

3. The current on the winding of a delta-delta connected transformer is .58 times the line CURRENT.

4. The voltage on the windings of a wye-wye connected transformer is equal to .58 times the line VOLTAGE.

5. The current on the windings of a wye-wye connected transformer is equal to the LINE current.

6. What two basic installation precautions should be followed in mounting any transformer?

   a. PROPER LOCATION

   b. PROPER MOUNTING

7. List two reasons for connecting the primary and secondary neutrals in wye-wye connected transformers:

   a. LINE TO NEUTRAL VOLTAGES WOULD BE VERY UNSTABLE

   b. INSULATION STRESSES WOULD RESULT BECAUSE OF UNSTABLE VOLTAGE

8. A bank of three transformers connected wye-wye are to supply a load of 300 KVA. What is the size of each transformer? $\frac{300}{3}$ = 100 KVA EACH

9. A three-phase transformer is three SINGLE phase transformers connected in SERIES and enclosed in a single housing.

10. What type transformer connection is the least expensive to install?
OPEN DELTA

11. In a delta-wye connected transformer bank, the secondary voltage is 1.73 larger than a delta-delta connected bank.

12. A step-up transformer INCREASES the voltage and DECREASES the current.

13. List two disadvantages of the open delta transformer connection:

a. LARGE UNBALANCE IN SECONDARY VOLTAGE

b. LARGE UNBALANCE IN PRIMARY CURRENT

14. In an open delta bank connection, the transformer's capacities must be 15.5 % larger than delta or wye connected bank.

15. Taps on a transformer are used for CHANGING the voltage by a small amount - usually 2 1/2 % per step.

FIXED ELECTRIC SPACE HEATING

DESIRED RESULTS:

1. To study the requirements of the N. E. Code concerning installation of fixed space heating.

2. To learn the various ways fixed space heating equipment shall be installed for approval.

REFERENCE:

Film on Space Heating, if available.

INTRODUCTION:

All fixed electric space heating equipment shall be installed in an approved manner. The equipment shall be of a type approved for the purpose and location where installed. The heating equipment may be heating cable, unit heaters, boilers, central systems, or other approved fixed electric space heating equipment.

This lesson does not cover process heating and room air conditioning. Fixed electric space heating equipment using a sealed (hermetic-type) motor compressor shall comply with Article 440 of the N. E. Code. Any space heating equipment for use in hazardous locations shall be installed to conform with Articles 500 through 517.

PRESENTING THE LESSON:

After the students have studied the assignment and looked up and answered the questions on the worksheets, the instructor should point out the main points of the N. E. Code concerning space heating. A film on the subject is recommended to compare Electric Space Heating with other forms of heating and to show methods of installation.

It may be desirable to figure the cost of a system for a modern home or office space. The apprentice will get acquainted with the equipment and how to install it.

CHECKING AND FOLLOW-UP:

When the students have completed the questions on the worksheet, they should be checked and returned to them for correction and filing in their notebooks.

NAME ______________________________ LESSON B-6

DATE ______________________________ WORKSHEET

FIXED ELECTRIC SPACE HEATING

1. What are the eight main types of fixed electric space heating equipment?

   a. ELECTRIC FURNACES
   b. HYDRONIC ELECTRIC BOILER
   c. HEAT PUMP
   d. BASEBOARD HEATERS
   e. ELECTRIC FIREPLACES
   f. FLOOR CABLES
   g. DUCT HEATERS
   h. INFRARED HEATERS

   *ALTERNATE ANSWERS

   *WALL MOUNTED HEATERS - RADIANT,
   FORCED AIR
   *CEILING MOUNTED HEATERS - HEAT VENT
   LIGHT COMBINATIONS, RESISTANCE
   HEATERS, RADIANT LAMPS, RADIANT
   PANELS, CEILING CABLES
   *UNIT HEATERS

2. The size of branch-circuit conductors supplying fixed electric space heating equipment shall be sized on the basis of 125 % of the total connected load.

3. The overcurrent protective device for the above branch circuit conductor must be sized for 125 % of the total connected load.

4. How would you know if an electric heater was approved for installation in a damp location or mounted directly on a combustible surface?
   THE EQUIPMENT WOULD HAVE THE U.L. LABEL ATTACHED LISTING APPROVAL FOR SUCH INSTALLATIONS.

5. An individual branch circuit may supply ANY ampacity circuit for fixed space heating equipment.

6. If the branch circuit supplies two or more outlets for fixed electric space heating equipment, the size is limited to 30 amperes.

7. A thermostat with an "OFF" position which does not open all ungrounded conductors can be used as the heater disconnect. Yes/No NO
   Give the Code section for your answer. 424-20 (A)

8. The maximum overcurrent protection for resistance-type space heating equipment is 60 amperes. The maximum load shall not exceed 48 amperes.

9. The maximum overcurrent protection for infrared electric space heating equipment is 50 amperes.

10. Match the identifying colored lead wires with the proper voltage of heating cable.

Red C

Yellow A

Blue B

Brown D

(a) 120 volts

(b) 208 volts

(c) 240 volts

(d) 277 volts

11. Is it necessary to apply a correction factor for wiring above a heated ceiling which has two inches of insulation? Yes/No NO
Give the Code section for your answer. 424 - 36 EXCEPTION

12. Each unit of fixed electric space heating equipment shall be marked with the rating in volts and AMPERES or volts and WATTS .

13. Heat panels and ceiling cables shall be at least 8 inches from the edge of surface mounted fixture outlet boxes and 2 inches from recessed fixtures and ventilating openings.

14. The fan and duct heater circuits must be INTERLOCKED so the movement of air across the heater is assured.

15. The duct heater disconnect must be AT or within SIGHT of the duct heater controller.

OUTDOOR DE-ICING AND SNOW MELTING EQUIPMENT

DESIRED RESULTS:

1. To become acquainted with electrically energized heating units, panels and cables used for de-icing and snow melting.

2. To learn how to install de-icing and snow melting equipment according to the N. E. Code.

INTRODUCTION:

The first units of electrically energized heating units, panels, and cables were embedded in driveways, walks, steps, and on streets that frequently iced near dangerous intersections. In these installations all requirements of the Code shall apply where applicable.

NOTE: Fixed outdoor electric de-icing and snow melting equipment shall be: (1) considered as continuous load for sizing branch circuits, and (2) installed according to Sec. 210-24.

PRESENTING THE LESSON:

Call to the attention of the apprentice that this special type equipment (units, panels, and cables) are fabricated and supplied by the manufacturer and should not be altered. Except that the non-heating leads may be shortened if the marking specified in Section 426-26 is retained. Units without NAME PLATES shall not be installed.

Point out the other Code requirements that may be different than regular installations. Stress the markings, junction boxes, and grounding methods.

The installations must be inspected and approved before being covered.

NOTE: The class should observe an installation of this equipment if convenient.

CHECKING AND FOLLOW-UP:

Check the completed worksheets against your answer sheet and return to the students for placing in their notebooks.

NAME ____________________ LESSON No. B-7

DATE ____________________ WORKSHEET

DE-ICING AND SNOW MELTING EQUIPMENT

1. Eave, gutter, and down-spout de-icing cables are covered in Article 426 of the N. E. Code. What section would it be covered under? 426-9

2. The load for de-icing and snow-melting equipment is considered as CONTINUOUS. This means the overcurrent protective device and the branch circuit conductor must be sized for 125 % of the load.

3. The maximum branch circuit overcurrent protective device for de-icing and snow-melting equipment is 50 amperes. Give the N. E. Code section for your answer. 426-3

4. Can the non-heating leads of de-icing and snow-melting equipment be shortened? Yes/No YES Give the N. E. Code section for your answer. 426-11 (A) Is this different from indoor ceiling and floor cable installations? Yes/No YES Give the N. E. Code section for your answer. 424-43 (C)

5. Under what conditions can an automatic snow-melting control device be considered as the circuit disconnecting means?

   a. INDICATE AN "OFF" POSITION

   b. OPEN ALL UNGROUNDED CONDUCTORS

   c. CIRCUIT CANNOT BE AUTOMATICALLY ENERGIZED IN MANUALLY "OFF" POSITION.

6. The nominal covering for embedded cables is 1 1/2 inches below the surface.

7. The Code requires cables to be tested before COVERING. The careful electrician will test the cable before installation, before COVERING, and AFTER covering.

8. What six basic installation rules should be followed for installing de-icing and snow-melting equipment?

   a. INSTALLED AS DESIGNED FOR USE IN THE MATERIAL

   b. UNITS SHALL NOT EXCEED 120 WATTS PER SQUARE FOOT

(over)

c. SPACING OF CABLE RUNS - 1 INCH ON CENTER MINIMUM

d. COVERING DEPTH AS REQUIRED FOR EMBEDDING MATERIAL

e. SECURE CABLES IN PLACE

f. PROTECTION AT EXPANSION JOINTS

9. What code section covers Branch Circuit requirements on fixed Electric Heating for pipeline and vessels. 427-4

10. When using a temperature-controlled switching device which indicates an off position, is it required to open all ungrounded conducts? YES. Give code section. 427-21

11. Do the metal parts of electric heating equipment for pipe line and vessels need to be grounded. YES Give code section. 427-26

65

GENERAL INSTALLATION REQUIREMENTS

DESIRED RESULTS:

To acquaint the apprentice with the general installation provisions required or permitted by the Code for electric wiring and equipment.

REFERENCES:

1. National Electrical Code, Article 110
2. State and Local Electrical Codes & Ordinances

INTRODUCTION:

The requirements set forth in this section of the Code are general in nature and must be considered whenever an electrical installation is made. These provisions apply to all wiring and equipment installations unless specifically exempted by other sections of the Code. Therefore, the students should learn them well. Be sure that they study the entire article and not just find the answers to the questions.

It should be clearly understood that the apprentice wireman is not expected to memorize the contents of either the National Electrical Code or State and Local Safety Orders or Ordinances.

PRESENTING THE LESSON:

A. Studying article 110.

   1. Study the definitions of the following terms, which are listed in Article 100 of the NEC: accessible, approved, concealed, device and enclosed.
   2. Study the Mandatory rules and Explanatory Materials and how they are presented.
   3. Give attention to sections concerning conductors, equipment, and connections to terminals 110-6 thru 110-15.

B. Questions for discussion.

   1. Are electrical fire hazards the same in small communities as in large cities?
   2. Do you think there should be a single, universal electrical code? Why?
   3. Would it be wise to leave the matter of electrical requirements solely to the electrical wireman? To the electrical contractor?

4. Suppose you own a large building without electrical wiring. There are no electrical laws in the state or community. Ten electrical contractors wish to bid on the job of wiring the building. (a) What problems would you face in trying to decide who should get the work? (b) Suppose, in this case, there was a national ordinance. Would decision be made easier? (c) Suppose, again, that there are state and local ordinances covering electrical installations. How would this fact help you in making the decision?

APPLICATION:

Have the class answer the questions on the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students for correction and placing in their workbooks.

NAME ______________________ LESSON NO. B-8

DATE ______________________ WORKSHEET

GENERAL INSTALLATION PROVISIONS

1. What does Article 110 of the National Electrical Code cover?

110-1 GENERAL REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

2. The Code requires that conductors and equipment be approved. What is meant by approved? 110-2 AND DEFINITION 100

ONLY WHEN ACCEPTABLE TO THE AUTHORITY ENFORCING THIS CODE.

3. Match Column A with Code Numbers in Column B.

		Column A		Column B
4	(a)	Mandatory Rules	(1)	110-6
3	(b)	Circuit Voltage	(2)	110-8
1	(c)	Conductor Gages	(3)	110-4
2	(d)	Wiring Methods	(4)	110-1
			(5)	110-9

4. Give Code section that tells how all equipment shall be installed.

110-12 How shall it be installed? INSTALLED IN A NEAT AND WORKMANLIKE MANNER.

5. TRUE OR FALSE - Mark T or F on line after statement and give Code references.

   (a) All electrical equipment shall be identified by the manufacturer's name or trademark. T Reference 110-21

   (b) When the wiring system is completed, all wiring shall be free from short circuits and grounds. T Reference 110-7

   (c) The Code permits you to put a shelf (for storage purposes) across the front of a panel if it is a removable type. F Reference 110-16 (B)

   (d) All conductors shall be spliced or joined with approved splicing devices. T Reference 110-14 (B)

(e) The Code permits the use of wooden pegs driven into holes in masonry walls to fasten electrical equipment to the wall.
F Reference 110-13 - (A)

(f) If equipment operates at more than 50 volts, and not more than 600 volts is elevated at least 8 feet above the floor it does not need to have a guard over "live parts." T
110-17 (A-4)

GROUNDED CONDUCTORS

DESIRED RESULTS:

To acquaint the apprentice with the code concerning Grounded Conductors.

INTRODUCTION AND PRESENTATION:

The subject of "grounding" is very important in our work as electricians. Proper grounding insures safety for life and property. There are two general headings or types of grounding; namely, equipment and system grounding. This assignment will introduce you to the many rules and requirements for this subject. This section of the Code should be studied very carefully. A "system ground" is a connection to ground from one of the current carrying conductors of a distribution system or of an interior wiring system. An "equipment ground" is a connection to ground from one or more of the non-current carrying metal parts of the wiring system. The term equipment used here includes all such metal parts as metal conduit and raceways, metal armor of cables, outlet boxes, switch boxes, and metal motor frames. The grounding conductor may be attached to the nearest cold water pipe.

All interior wiring systems, except as provided in sections of the Code, shall have a grounded conductor. This conductor shall be identified throughout the system except as explained in the section of the Code called "Unidentified Circuits." In some hazardous locations, such as hospital operating rooms, it may be desirable to install ungrounded circuits. Such ungrounded circuits must be connected to a system which is provided with a contact indicating a device that will warn the occupants of a faulty ground.

1. Study the definitions for the following terms which are listed in Article 100 of NEC: Ground, Grounded, Grounded Conductor, Grounding Conductor, Equipment.
2. Study the assigned sections of the Code very carefully.
3. Stress any particular applications noted in sections of this article which are vital in your area.

APPLICATION:

Have the students complete the answers to the questions on the assignment sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the students.

NAME ______________________ LESSON No. B-9

DATE ______________________ WORKSHEET

GROUNDED CONDUCTORS

1. All interior wiring systems shall have a grounded conductor. How is this conductor identified? WHITE OR NATURAL GRAY COLOR

2. In the following wiring methods, how is the Grounded Conductor identified?

   a. MI Cable MARKED BY WHITE TAPE OR PAINT DURING INSTALLATION

   b. Conductors # 6 or smaller in conduit OUTER COVERING OF WHITE OR NATURAL GRAY COLOR

   c. Conductors larger than # 6. EITHER COLORED INSULATION OR WHITE COLOR CODING TAPE.

   d. A 4-wire Delta-connected secondary - the mid-point of one phase grounded to feed lighting loads. How shall the "High Leg" be marked at the point of connection if the neutral conductor is present. MARKED ORANGE IN COLOR OR TAGGED

3. In cable wiring, what section of the N. E. Code allows the identified conductor (white wire) to be used as the "return conductor" from the switch to the outlet? ARTICLE 200-7 EXCEPTION 2 "ANSWER IS NONE"

4. Grounded conductor shall be connected to SCREW - SHELL terminal.

5. Identified conductor shall be connected to identified WHITE colored terminal to screw-shell.

6. Grounded terminal shall be identified by WHITE METALLIC coating.

7. The equipment grounding conductor terminal on the receptacle shall be GREEN color.

8. The grounded circuit conductor terminal on the receptacle shall be WHITE color.

9. Switching devices in each tapped circuit shall have a pole in each UNGROUNDED conductor and the poles shall operate SIMULTANEOUSLY.

10. Can an autotransformer be installed to step up a 208 volt 1 Ø circuit for a 240 volt 1 Ø range? Yes/No YES
Give the N.E. Code Article to justify your answer. ARTICLE 210-9 EXCEPTION #2

GROUNDING

DESIRED RESULTS:

1. To acquaint the apprentice with the Code regulations for the protection of electric installations by grounding.
2. To understand the difference between "system grounds" and "equipment grounds," and how to ground them.
3. To study the methods of grounding and the sizes of conductors used.

INTRODUCTION:

Protection of electric installations by grounding is very important work for the electrician. Insulation, isolation, and guarding are suitable alternatives under certain conditions. A good example of the need in some installations for isolated or insulated ungrounded circuits is covered in the Code section for hospital operating rooms.

A "system ground" is a connection to ground from one of the current-carrying conductors of a distribution system or of an interior wiring system. An "equipment ground" is a connection to ground from one or more of the non-current-carrying metal parts of the wiring system or of apparatus connected to the system. The term "equipment" includes all the materials with metal parts used in the installation, such as metal conduit, raceways, outlet boxes, cabinets, switch boxes, motor frames, and metal enclosures for motor controllers.

PRESENTING THE LESSON:

Circuits are grounded for the purpose of limiting the voltage upon the circuit which might otherwise occur through exposure to lightning or other voltages higher than that for which the circuit is designed; or to limit the maximum potential to ground due to normal voltage.

Give examples of grounding systems encountered:

1. Transformer grounding.

2. An interior wiring system grounded at the service entrance.

3. System with neutral ungrounded, with voltages to ground with an accidental ground on one conductor.

4. Instrument transformers, relays, and switchboards.

APPLICATION:

Have the students complete the assignment sheets for this lesson.

CHECKING AND FOLLOW-UP:

Check the assignment sheets and return to the student for correction.

NAME ______________________ **LESSON B-10**

DATE ______________________ **WORKSHEET**

GROUNDING

1. List two types of grounds used in an interior wiring system.

   a. SYSTEM GROUND (NEUTRAL)

   b. EQUIPMENT GROUND

2. The EQUIPMENT ground connects the non-current-carrying metal parts of the wiring system or equipment to GROUND.

3. In interior wiring systems, the IDENTIFIED—OR NEUTRAL conductor shall be grounded.

4. Bonding jumpers shall be used to connect isolated equipment to GROUNDED equipment.

5. The minimum copper grounding conductor for an A.C. system shall be No. 8 AWG.

6. The maximum copper grounding conductor required for an A.C. system is No. 12 1/2 % x Serries Phase Conductor in some cases, as when phase conductor size in larger than 1100 MCM.

7. The minimum copper grounding conductor for an A.C. system with 250 MCM service entrance conductors shall be No. 2 AWG.

8. The minimum copper equipment ground conductor for a 60-ampere circuit shall be No. 10 AWG.

9. The resistance of made electrodes shall not exceed 25 ohms.

10. The minimum length of buried metallic water piping system permitted as a grounding electrode shall be 10 feet.

11. In general, underground water pipes have a resistance to ground of less than 3 ohms.

12. Splice connections on the GROUNDING ELECTRODE. conductor is not permitted.

13. The equipment ground conductor shall be GREEN color or BARE.

14. In general metal enclosures for conductors shall be located a minimum of 6 feet from lightning rod grounding conductors.

15. Switchboard frames shall be GROUNDED regardless of VOLTAGE.

16. All portable tools shall be GROUNDED.

17. Service entrance conduit shall be GROUNDED.

18. A grounding conductor in cord shall be provided for cord-connected FIXED equipment.

19. Metal frame constructed building shall be GROUNDED.

20. Frames of electric ranges and clothes dryer shall be GROUNDED.

21. List at least five approved types of grounding electrodes.

a. METALLIC WATER PIPE
b. CONCRETE-ENCASED ELECTRODE
c. PLATE ELECTRODE
d. PIPE OR CONDUIT ELECTRODES
e. ROD ELECTRODES

BRANCH CIRCUITS

DESIRED RESULTS:

To acquaint the apprentice with the requirements of the Code concerning branch circuits.

INTRODUCTION:

Most of the electrical work to be done on any job will be concerned with Branch Circuits. The apprentice should become familiar with the requirements of the Code concerning these circuits. To know these requirements and carry them out on the job will become the electrician's "bread and butter." The apprentice should study this section carefully before attempting to answer the questions on the assignment sheet.

PRESENTING THE LESSON:

1. Study the definitions for the following terms listed in Article 100 of the NEC: Branch Circuit, Branch Circuit (Appliance), Branch Circuit (General Purpose), Branch Circuit (Individual).

2. Discuss:
   a The scope of branch circuits.
   b. Exceptions to the provisions in Article 210.
   c. Classification of branch circuits.
   d. What is a Multi-Wire Branch Circuit?
   e. What "Color Code" is required for a five-wire branch circuit?
   f. What is a Heavy-Duty lampholder?

3. What is meant by "Adequate Wiring"?
   a. Discuss the minimums required by the Code.
   b. Name the two handbooks which contain data on the design of adequate wiring.

4. Review the Calculation of Load
   a. For General Lighting.
   b. Other outlets supplying specific appliances and heavy-duty lampholders.
   c. Additions to existing installations.

5. Discuss specific requirements for:
   a. Conductors
   b. Overcurrent Protection
   c. Outlets Required
   d. Maximum Load
   e. Permissible Loads

APPLICATION:

After studying and reviewing the Code requirements, have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheets to the class for correction and placing in their workbooks.

NAME ______________________ LESSON B-11

DATE ______________________ WORKSHEET

BRANCH CIRCUITS

1. What Article covers branch circuits supplying lighting or appliance load or a combination of such loads? NEC ARTICLE 210

2. Where conductors of different systems are installed in the same gutter or raceway, handling more than one identified conductor, how shall they be marked? FIRST NEUTRAL CONDUCTOR WHITE OR GREY; OTHER NEUTRAL CONDUCTOR WHITE WITH COLORED STRIPE. Reference ART. 210-5 (A)

3. What amount of voltage drop is permitted on power, heating lighting, or combination Branch Circuits, List code section. 210-19 A.

4. (a) What section of the Code covers ground-fault circuit protection on 15 and 20 ampere receptacle outlets on single phase circuit at construction sites? 210-8 (B).

5. Would a fixed room divider, bar-type counters count in the 6 foot rule for receptacles? Yes/No YES Code Section Reference 210-24-B.

6. There have been changes made in the Requirements for Receptacles in Kitchens and Din~~n~~ing Room areas. What are the requirements now? Reference 210-24 (B). Remarks EACH COUNTER SPACE 12 INCHES OR GREATER

7. Does the Code prohibit the use of a conductor having a green covering for internal wiring of equipment? Yes/No YES Code Section Reference 210-5 (B) EX.# 2

8. Give minimum size copper conductor for the following branch circuit classification (75°C).

   (a) 15 ampere branch circuit #14 AWG

   (b) 20 ampere branch circuit #12 AWG

   (c) 30 ampere branch circuit #10 AWG

   (d) 65 ampere branch circuit # 6 AWG

210-3

AND

TABLE 310-16

FOR 75 ° WIRE

(COPPER)

9. The Code requires additional receptacles above the 200 watts per linear ft. in show window.

   (a) Give Section 210-25 (D)

   (b) Where are they located? ONE RECEPTACLE FOR EACH 12 LINEAR FT. ABOVE THE SHOW WINDOW.

10. What is a multiwire branch circuit? ARTICLE 100 DEFINITION AND

Reference Code ART. 210-4

80

APPLIANCES

DESIRED RESULTS:

1. To determine the load that branch circuits shall conduct to insure safe operation of appliances.

2. To become acquainted with the classes of appliances and how to install circuits to insure safe operation.

INTRODUCTION:

This lesson shall apply to electrical appliances used in any occupancy. Equipment shall be of a type approved for the purpose and location where installed. Call attention to the fact that no live parts shall be exposed on appliances except for toasters, grills, etc. Appliances for use in hazardous locations shall be installed to conform to Articles 500 through 517. The requirements of Article 430 apply to the installation of motor-operated appliances.

The rating of an individual branch circuit shall not be less than the marked rating of the appliance or the marked rating of an appliance having combined loads.

APPLICATION:

Have the students discuss typical installations to be used locally. How are flexible cords made; give the requirements for their use on on appliances.

After the students have answered the questions on the worksheet, they can exchange papers and check the answers.

FOLLOW-UP:

Return the checked papers to the students for correction, discussion, and filing in their notebooks.

NAME ____________________ LESSON No. B-12

DATE ____________________ WORKSHEET

APPLIANCES

1. What is meant by:

   a. Fixed appliance IS FASTENED OR SECURED TO ONE LOCATION

   b. Portable appliance ONE THAT IS ACTUALLY MOVED OR CAN EASILY BE MOVED FROM ONE LOCATION TO ANOTHER

   c. Stationary appliance CANNOT BE EASILY MOVED FORM ONE LOCATION TO ANOTHER IN NORMAL USE.

2. What are the Branch Circuit requirements for small appliances in a residence? TWO OR MORE 20 AMPERE BRANCH CIRCUITS 220-3-B

3. Does the Code require you to put a laundry circuit in all dwellings? NO. Give Code section to back up answer. 210-25 (B)

4. In calculating the feeder load, are you allowed to apply demand in table 220-11 to the small appliance load? Yes 220-16 (A)

5. Is it permissible to load a circuit to its capacity with portable or stationary appliances? NO (80%) 220-2-A

6. What would be the feeder load for five ranges rated at 11.5 kw each?
   20 KW 220-19 TABLE COLUMN A

7. What would be the feeder load for the same 5 ranges if the rating was 13 kw each. NOTE 1 TO TABLE 220-19 5% FOR EACH KW OVER 12: 20.250 WATTS OR 20.25 KW.

8. When there is a protective device rating marked on appliance, is it permissible to use a larger branch circuit overcurrent device?
   NO 422-6

9. Does the Code permit the use of flexible cord on fixed appliances?
   YES. Give Code section 422-8 (c)

10. Given a branch circuit supplying a single nonmotor-operated appliance and rated at **16.7** amperes or more, what is the maximum rating of the overcurrent device? 150%. Code Reference 422-27 (E).

FEEDERS AND BRANCH CIRCUIT CALCULATIONS

DESIRED RESULTS:

To teach the apprentice how to determine the minimum sizes of feeder conductors necessary for safety.

INTRODUCTION:

This topic is concerned largely with feeder requirements for apartment houses and stores. Although the basic rules are the same as for the single dwelling, the additional rules are more complex. For example, it is often the job of the electrician to install the single-phase, three-wire service entrance for an apartment building. He has the problem of determining the size of the conductors and conduit for the service entrance.

It is also necessary to determine the size of the subfeeders for each apartment. Of particular interest in this assignment is the method for determining demand load for groups of electric ranges in an apartment house, It is not necessary to memorize the requirements listed for groups of ranges or other fixed appliances. It is wise to spend enough time studying the notes appended to the table to make certain that methods for determining service and feeder demand factors are thoroughly understood.

PRESENTING THE LESSON:

Study the following sections: Feeder Size; Normal Voltage and Voltage Drop; Calculation of Load; Computation of Feeder Sizes and Common Neutral Feeder.

After the students have studied the above sections, the instructor should go through each topic with them and point out the important items.

DEMONSTRATIONS: (Computation of Feeder Sizes--Examples.)

I. Maximum Demands for Range Loads
   (Use examples in code book)
II. Single-family dwelling
   (Use examples in code book)
III. Multi-family dwellings (apartment building)
   (Use examples in code book)

APPLICATION:

Have the students fill in the answers to questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

After checking the answers, have the students correct the errors and place the sheets in their workbooks.

NAME ______________________ LESSON NO. B-13

DATE ______________________ WORKSHEET

FEEDERS AND BRANCH CIRCUIT CALCULATION

1. Name the five basic items that should be included in a feeder diagram.

(a) AREA IN SQUARE FEET (215-5)

(b) LOAD (BEFORE APPLYING DEMAND FACTORS)

(c) DEMAND FACTORS SELECTED

(d) COMPUTED LOAD (AFTER APPLYING DEMAND FACTORS)

(e) SIZE OF CONDUCTORS

2. Give Unit Load per square ft. for General Lighting Load that applies to the following:

	Answer	References
(a) Banks	5	220-2 (B)
(b) Court Rooms	2	"
(c) Office Building	5	"
(d) Dwellings (Other than Hotels)	3	"
(e) Schools	3	"
(f) Restaurants	2	"

3. How many circuits would be required for General Lighting in a dwelling having 2100 square ft.? 5 CIRCUITS. Give Code section reference 220-3 (A)

4. When calculating load for a dwelling, is the demand factor applied to the 2 kitchen and laundry circuits? KITCHEN CIRCUIT - YES
LAUNDRY CIRCUIT - YES
Reference 220-16(A&B)

5. When computing the square footage of a building for a general lighting load, what dimensions are used? OUTSIDE Code Section Reference 220-2 (B)

6. Find the minimum size lighting feeder (THW) Copper for an office building 6 floors, 75 feet by 125 feet each. The service is a 4-wire 3 phase 120/208 volts.

Sq. ft. = 75 x 125 = 9375 sq. ft. each floor
220-2 (a) table 9375 sq. ft. x 5 watts = 46,875 watts per floor
6 x 46,875 = 281,250 watts
281,250 + 25% = 351562.5 watts continuous load 220-4 (a)
watts ÷ voltage = 351,532 ÷ 360 = 976 amps
800 MCM - Parallel 8 conductors table 310-16
or 400 MCM - Parallel 3 sets 12 conductors

2-800 MCM Per Phase
Conductor, or
3-400MCM - Per Phase
75% Cu.

7. Give feeder load demand for the following: [Use Table 220-11]

(a) Restaurants 100%

(b) Schools 100%

(c) Stores 100%

(d) Warehouse Storage First 12,500 @ 100%; remainder over 12,500 @ 50%

(e) Banks 100%

(f) Courtrooms 100%

8. Calculate the minimum service for a dwelling of 1800 square feet, having 12 kw range, 5 kw water heater, 1.5 kw dishwasher, 5 kw dryer, 5 - 1.5 kw space heaters, and 3 HP 230 V air conditioning units. (Use optional method 220-30) Voltage 115/230 volts, single phase.
References 220-2 (a) 220-3 (b) 220-3 (b)

1800 sq. ft. at 3 watts = 5400 watts
2 small app. cirs. at 1500 watts each
1 laundry cir. at 1500 watts

Omit Air Condition 220-21
430-148

General Light	5400	watts
Small App.	3000	watts
Laundry	1500	watts
Dishwasher	1500	watts
Water Heater	5000	watts
Range	1200	watts
Dryer	5000	watts
5 Space Heaters	7500	watts
	30,100	watts

First 10 kw at 100% 10,000 watts
Remainder at 40% 20.1 kw x 40 = 8,040 watts
22,360 watts total 18040=78.4A or 100A

18040W÷230=78.4A or 100A

9. Give feeder kw load for twelve (12) ranges rated at 11 kw each.
27 Reference COL A 220-19

SERVICES

DESIRED RESULTS:

1. To understand the connections of standard single-phase, three-wire service entrances.
2. To understand the requirements of the National Electrical Code and power utility companies for a typical single family dwelling.

INTRODUCTION:

In general, a building shall be supplied with electricity through only one set of service conductors. A building may be supplied by two or more service drops when there is good reason for this arrangement. (See Sections 230-2)

The service entrance for most present day lighting installations is a single-phase, three-wire service. The middle wire is called the neutral wire and is grounded; it is identified by the white insulation. The two outside wires are known as the hot wires. The voltage between the neutral wire and either of the hot wires is 115 volts, and the voltage between the two hot wires is 230 volts.

In these modern times with the many electrical appliances, it is a definite advantage to have both 115 and 230 volts available. Many types of loads, such as electric water heaters, electric ranges, and fractional horsepower motors, operate on 230 volts. The higher voltage is preferable because heating appliances and motors will take less current. This permits the use of smaller wires, results in less voltage drop and less wasted power.

PRESENTING THE LESSON:

After the students have read Article 230, the instructor should point out the fundamental rules of the National Electrical Code. The rules concerning the calculations affecting the service entrance switch, service entrance conductors, and grounding should be called to their attention.

Using the information sheets provided the students, review how to determine the number of circuits, the rating in volts and amperes, and the wire sizes for a typical, single family dwelling. This dwelling will have three bedrooms with a living area of 1500 square feet. The modern appliances scheduled for this home, including six space heating units, are listed. Determine the size panel to be installed to accommodate these circuits.

APPLICATION AND CHECKING AND FOLLOW-UP:

The students will complete the answers on the assignment sheets for this lesson. Then, check the answers and return to students for correction and filing in their workbooks.

INFORMATION SHEET LESSON B-14

SERVICES FOR A TYPICAL DWELLING

A typical application for a 115/230 volt, single-phase, three wire service installation in a single family dwelling will be considered. It is the intent to give the apprentice the fundamental rules of the National Electrical Code insofar as they concern the calculations that affect the service entrance switch, service entrance conductors, and grounding. The branch circuits supplying the various items of electrical equipment will be discussed briefly. Since the metering of the electrical space heating equipment as well as electric water heaters varies with different power companies, the apprentice should check the requirements in the area.

The building under consideration will be a three-bedroom residence with an area of 1500 square feet.

A. The following appliances are scheduled for this home:

1. 3-kw water heater
2. 4.7-kw clothes dryer
3. 8 ampere 230-volt air conditioner
4. 11.1 ampere 115-volt dishwasher
5. 4-kw wall-mounted oven
6. 6-kw counter-mounted cooking unit
7. 7.5 ampere 115-volt garbage disposal
8. 2-kw space heating unit in each of 6 rooms

B. Calculations:

1. Determine the Number of Lighting Circuits

Calculate the load based on the "watts per square foot" method.
1500 sq. ft. x 3 watts per sq. ft. - 4500 watts

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{4500}{115} = 39.1 \text{ or } 40 \text{ amperes}$$

Generally, 15-ampere lighting circuits are installed in residential buildings using No. 14 AWG conductors. Some electrical specifications require No. 12 AWG conductors as a minimum on all circuits. Then $\frac{40}{15} = 2$ plus or 3

Note: In a residence of this type, there may be as many as 60 outlets. Most electricians prefer to limit the number of outlets per circuit to 8 or 10, thus there would be 6 circuits installed.

2. Small Appliances

Most electricians prefer to run three 20 ampere circuits for small appliances to be used in the ktichen, laundry, pantry, dining room, and breakfast room areas. It is a code requirement to install a separate 20 ampere circuit for the laundry outlet and divide the outlets in the kitchen and dining room area between the other 20 ampere circuits. The use of No. 12 wire instead of No. 14 wire to minimize the voltage drop, improves the performance of the appliances and lessens the danger of overload.

3. Clothes Dryer

The electric clothes dryer is rated 4.7 kw at 230 volts. The load value in watts is 4700.

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{4700}{230} = 20.4 \text{ amperes}$$

The circuit to the dryer will be a 30 ampere 115/230 volt, 3 wire circuit of two No. 10 AWG conductors and one No. 12 AWG for the neutral conductor. The neutral may be smaller than the phase wires because it carries only the current of the motor and the light.

4. Air Conditioning

The load is 8 amperes x 230 volts = 1840 watts. It will be connected to a 15 ampere, 230 volt circuit with No. 14 AWG conductors. Circuits for air conditioners must conform to the provisions of the Code.

5. Dishwasher

The load is 11.1 amperes x 115 volts = 1276 watts. This unit will be supplied by a separate 15-ampere circuit using No. 14 AWG wire.

6. Garbage Disposal

The load is 7.5 amperes x 115 volts = 852 watts. This circuit will be supplied by a separate 15-ampere circuit which requires No. 14 AWG wire.

7. Wall-Mounted Oven

The oven is rated 4-kw at 115/230 volts and will be connected to a separate circuit. The load value in watts is 4000.

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{4000}{230} = 17.4 \text{ amperes}$$

According to the table No. 12 AWG conductor may be used for this circuit. NEC - 250- 60, Ground with No. 10.

8. Counter-Mounted Cooking Unit

The surface cooking unit is rated 6 kw at 115/230 volts and will be connected to a separate circuit consisting of three No. 10 AWG conductors supplied by a 30-ampere, 2 pole overcurrent device.

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{6000}{230} = 26 \text{ (approx.) amperes}$$

Note: The Code permits the use of one 50-ampere circuit to supply these two units, provided the individual taps to the 50-ampere circuit are not longer than necessary for servicing.

9. Electric Space Heating

Six 2 kw electric space heating units will be installed with a thermostat which provides individual room control for heating purposes. Also, it is necessary that there be four or more individually controlled electric space heating units in order to apply certain demand factors permitted by the Code used in calculating service-entrance capacity. Each of these units is rated at 2 kw and 230 volt circuit.

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{2000}{230} = 8.7 \text{ amperes}$$

Each separate unit will be connected to a separate 15-ampere, 230 volt circuit using No. 14 AWG wire.

10. Water Heater

The water heater in this residence is rated at 3-kw.

$$\text{Amperes} = \frac{\text{watts}}{\text{volts}} = \frac{3000}{230} = 13 \text{ amperes}$$

Connected for unlimited demand, the maximum current would be 13 amperes and No. 14 AWG could be used. However, for a load that so closely approaches the maximum current-carrying capacity of No. 14 AWG, most electricians would install No. 12 AWG (20 ampere) and connect it to a 15 ampere, 230 circuit.

Note: Consult local utility for proper connections of water heaters because some require a special "off-peak" meter and others use special methods to cover the power consumption.

11. Ground fault circuit protectors are required for all outside outlets and in each bathroom. These can either be G.F. circuit breakers in the panel or G.F. receptacles at the outlet.

SUMMARY OF SERVICES FOR 1500 SQ. FT. DWELLING

Use of Circuits	No. of Circuits	Rating		Wire Size
		Volts	Amperes	AWG
General Lighting	6	115	15	14
Small Appliances	3	115	20	12
Garbage Disposal	1	115	15	14
Dishwasher	1	115	15	14
Dryer	1	115/230	30	10
Oven	1	115/230	20	12
Counter Cook Top	1	115/230	30	10
Air Conditioner	1	230	15	14
Water Heater	1	230	15	12
Space Heat	6	230	15	14

Service Entrance Switch

To accomodate the number of circuits listed in the summary, a 200-ampere panel will be installed. This panel will contain all of the required branch circuits plus a 200-ampere main pullout in one enclosure. This type of enclosure is approved by Underwriters' Laboratories, Inc. and should meet the Code requirements in most localities.

Ground Connection

The Code requires interior-alternating-current systems to be grounded. This is done by running a wire from the neutral connection in the main service switch or meter to a water pipe. Exceptions to the rule are specified in the Code.

NAME ______________________ LESSON B-14

DATE ______________________ WORKSHEET

SERVICES

1. What does the service consist of? SERVICE CONDUCTORS AND SERVICE EQUIPMENT Reference PAGE 9-177 & 346 A.E.H.

2. (a) What is meant by service drop conductors? THE OVERHEAD SERVICE CONDUCTORS FROM THE LAST POLE OR OTHER AERIAL SUPPORT TO AND INCLUDING THE SPLICES, IF ANY, CONNECTING TO THE SERVICE ENTRANCE CONDUCTORS AT THE BUILDING OR OTHER STRUCTURE.

   (b) What is meant by service-entrance conductors? (OVERHEAD) THE SERVICE CONDUCTORS BETWEEN THE TERMINALS OF THE SERVICE EQUIPMENT AND A POINT USUALLY OUTSIDE THE BUILDING, CLEAR OF BUILDING WALLS, WHERE JOINED BY TAP OR SPLICE TO THE SERVICE DROP.

3. List six conditions which permit more than one service drop to a building.

	THE CODE PERMITS 7	References
(a)		ART. 230-2
(b)		7 EXCEPTIONS
(c)		PAGE 9-179
(d)		SECTION (350) A.E.H.
(e)		
(f)		

4. True or False - Give answer T or F and explain or give reference.

TRUE (a) It is permissible to run a bare service conductor in conduit on exterior of a building. Reference 230-40 EXCEPTION # 1

TRUE (b) It is permissible to splice service entrance conductors. Reference 230-46

FALSE (c) The clearance of service drops across private driveway is 10 feet. Reference 230-24(B)

FALSE (d) The point of attachment to a building for service drops shall always be 10 feet. Reference 230-26

TRUE (e) The Code permits you to use six main disconnect switches on one service as long as they are grouped together. Reference 230-71(A)

TRUE (f) Each ungrounded service conductor must have overcurrent protection. Reference 230-90

TRUE (g) An enclosed service disconnecting means should be externally operable. Reference 230-76 (UNLESS POWER OPERATED)

TRUE (h) Ground-fault protection is required on services rated at 1,000 amperes or more. Reference 230-95 ("ON SYSTEMS OVER 150V TO GROUND AND NOT OVER 600V PHASE TO PHASE")

TRUE (i) Fire pumps require overcurrent protection.

TRUE (j) Drip loops should be formed in each service conductor to prevent the entrance of moisture.

5. Must there be means to disconnect the grounded conductor from the interior wiring, at the service disconnect switch? YES
Give Code Section Reference. 230-75

6. (a) Where are seals required on the underground service raceway?
WHERE IT ENDS AFTER ENTERING THE BUILDING
Give Code Section Reference. CODE 230-48

(b) Are seals required on spare underground service raceway? YES
Reference 230-48

7. Service equipment enclosures SHALL be grounded. (Should or Shall)
Give Code section. 230-63

8. Does the code require the disconnecting means to be inside the building it is to service? NO, CAN BE OUTSIDE ALSO Give Code section to back up your answer. 230-72 (C)

9. On a six family apartment building, is it permissible to locate all main disconnects in one apartment? NO Give Code section to back up your answer. NEC 230-72 (D) AMER. ELECT. HANDBOOK PAGE 9-160

10. Define a Master Service. A SERVICE THAT SUPPLIES MORE THAN ONE BUILDING UNDER A SINGLE MANAGEMENT.
Give your reference. ELECTRICIAN HANDBOOK PAGE 9-162

TEMPORARY SERVICES

DESIRED RESULTS:

1. Given a problematic situation concerning temporary wiring, the student will be able to locate the related section in the National Electrical Code book.
2. The student will be able to identify the equipment and supplies required for installing temporary feeders, branch circuits, and receptacles.

INTRODUCTION:

The Code provisions applicable for Temporary Electrical Power and lighting wiring methods are found in Article 305. These requirements may be of a class less than would be required for a permanent installation. Except as specifically modified in the Article 305, all other requirements of this Code for permanent wiring shall apply to temporary wiring installations.

PRESENTING THE LESSON:

Temporary services may be used during the period of construction, remodeling, or demolition of buildings, structures, equipment, or similar work.

Temporary wiring installations may be used for a period not to exceed 90 days for Christmas decorations, carnivals, and similar purposes.

Have the students research the Code for general services, feeder protection, origin of branch circuits, grounding, and disconnecting means for temporary wiring.

APPLICATION:

The students will complete the answers on the worksheet.

CHECKING AND FOLLOW-UP:

Exchange papers and check the wrong answers. Return papers and correct errors.

NAME ______________________________ LESSON B-15

DATE ______________________________ WORKSHEET

TEMPORARY SERVICES

True-False Questions--Circle correct answer and give reference or reason for your answer.

1. Temporary wiring methods are in a class by themselves. [✓ True]/False.
   Reference or Reason 305-1

2. Article 305 of the N. E. Code sets the requirements for temporary wiring. True/[✓ False].
   Reference or Reason 305-1

3. Temporary wiring can only be used for 90 days for any type temporary installation. True/[✓ False].
   Reference or Reason 305-1 (B)

4. Ground-fault circuit protection is required for all 15 and 20 ampere receptacle outlets. True/[✓ False].
   Reference or Reason 210-8

5. Can a two-wire 120 volt 15 ampere receptacle be used as an outlet for a 1/4 H. P. drill motor on a construction site? Yes/[✓ No].
   Reference or Reason 210-8

6. Does every branch circuit which supplies receptacles or fixed equipment have to contain a separate equipment grounding conductor? Yes/[✓ No]. 305-2 -D

7. Explain your answer to the question above. (No. 6)
   AN EQUIPMENT GROUNDING CONDUCTOR HAS TO BE RUN IF THERE IS NO METALLIC RACEWAY OR CABLE ASSEMBLY CONTAINING AN EQUIPMENT GROUNDING CONDUCTOR.

8. List 4 ways of running a branch circuit for temporary power and lighting.

(a) OPEN WIRING

(b) MULTI-CONDUCTOR CABLES

305-2-(B-C-E)

(c) MULTI-CONDUCTOR CORDS

(d) METALLIC RACEWAYS

9. Can the equipment grounding conductor be bare when it is installed with open wiring at the ceiling and supported every 10 feet. Yes/[✓ No].

Reference or Reason 305-2 (E)

10. A 3/4 inch diameter by 10 foot copper-clad ground rod is approved as an earth return for a receptacle which has no equipment grounding conductor in the circuit feeding the receptacle. True/[✓ False].

Reference or Reason 305-2 (E)

11. Overcurrent protective devices should be sized to the: (Choose best answer.)

___ (a) Ampacity of the load.

X (b) Ampacity of the conductors.

___ (c) Ampacity of the load plus 25%.

12. Three phase concrete block saws do not have to be grounded. True/[✓ False].

Reference or Reason 250-45

13. Can the grounding electrode conductor for a temporary wiring service be aluminum? [✓ Yes]/No.

14. Give the Code section to prove your answer to the above question.

250-91 (A)

15. Feeders and branch circuits shall originate in an approved distribution center or panelboard. What does the word "approved" cover?

(a) THE ENCLOSURE IS SUITABLE FOR THE ENVIRONMENT IN WHICH IT IS INSTALLED.

(b) IF USED AS SERVICE ENTRANCE EQUIPMENT, IT MUST BE LABELED AND LISTED AS APPROVED FOR SERVICE ENTRANCE EQUIPMENT.

(c) IT MUST BE SIZED TO CARRY THE AVAILABLE SHORT-CIRCUIT CURRENT AT THE SUPPLY TERMINAL.

OUTSIDE BRANCH CIRCUITS

DESIRED RESULTS:

1. To understand the meaning and function of outside branch circuits.
2. To become acquainted with the Code requirements for outside branch circuits and feeders.

REFERENCES:

1. National Electrical Code, Article 225
2. American Electricians' Handbook, Pages 8-46 thru 48

INTRODUCTION AND PRESENTATION:

The requirements of this article shall apply to electrical equipment and wiring for the supply of utilization equipment located on or attached to the outside of public and private premises or run between buildings, structures, or poles. It does not apply to wiring for signs and outside lighting, nor to equipment or wiring of an electric utility used in the exercise of its function as a utility.

These Code rules are not intended to regulate overhead distribution lines except as follows:

1. The safety of wiring systems in, on, or between buildings is affected.
2. Where on account of the proximity to a building, the safety of the building and its occupants is affected.

Rules are included here for wiring on the exteriors of buildings and on premises such as athletic fields, parking lots, and spaces temporarily used for fairs and carnivals.

Note the application of other Code Articles, including additional requirements to specific cases of equipment and conductors.

Reveiw the types of conductors, insulation and minimum size required for branch circuits. Discuss methods of supporting open conductors; clearance from ground; clearance from buildings for conductors not in excess of 600 volts.

What type lampholders are required and where should the lamps be located for outdoor lighting?

APPLICATION:

Have the students complete the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the Assignment Sheet and return to the students for correction and discussion.

NAME ______________________ LESSON B-16

DATE ______________________ WORKSHEET

OUTSIDE BRANCH CIRCUITS

1. Where conductors are in cable or raceways and within 10 feet of a building or any other structure, what type of insulation shall be used?

   a. RUBBER COVER

   b. THERMOPLASTIC

   c. WET LOCATIONS APPLICATIONS, 225-4 SEVERAL TYPES

2. Give the minimum size conductors for the following:

   a. Overhead spans #10 AWG UP TO 50 FT. SPANS #8 AWG FOR SPANS GREATER THAN 50 FEET. 225-6 (A)

   b. Festoon lighting 12 AWG UNLESS SUPPORTED BY MESSENGER WIRE. 225-6 (B)

   c. Over 600 volts #6 WHEN OPEN INDIVIDUAL CONDUCTORS AND #8 WHEN IN A CABLE ASSEMBLY. 225-6 (A)

3. What is minimum separation of conductors exposed to weather? Also support bracket separation? 225-14 (A) & 230-51 (C)

   1. SIX INCHES AND BRACKET SEPARATION OF 9 FT.
   2. TWELVE INCHES AND BRACKET SEPARATION OF 15 FT.
   3. OR THREE INCHES AND BRACKETS SEPARATION OF 4 1/2 FT. IF VOLTAGE IS 300 VOLTS OR LESS.

4. What are the minimum clearances in feet of open conductors not over 600 volts?

   a. Above finish grade 10 FT. (225-18)

   b. Residential driveways 12 FT.

   c. Parking lots not subject to truck traffic 15 FT.

   d. Public streets 18 FT.

   e. Over roof 8 FT. (225-19)

5. How shall open conductors be supported? GLASS OR PORCELAIN KNOBS, RACKS, BRACKETS, OR STRAIN INSULATORS (225-12)

6. What is the maximum branch circuit voltage supplying lamp holders or lighting fixtures mounted on outside of buildings or on poles or structures for area illumination of residential, commercial, or industrial property? 225-7 (c) 150 VOLTS UNLESS IT MEETS REQUIREMENTS OR EXCEPTIONS 1 AND 2.

D.C. MOTORS AND GENERATORS

DESIRED RESULTS:

1. To acquaint the students with the principal types of D. C. motors and generators and where they are used.
2. To learn how to install or connect conductors with the motors used under special conditions.

INTRODUCTION AND PRESENTING THE LESSON:

D. C. motors and generators are mostly used as emergency systems in healthcare facilities, stand-by power, and generation systems.

1. Call attention to the many definitions in 517-2 of the Code concerning Health Care Facilities.
2. Discuss the Emergency System in Code 700 and Life Safety Branch in Code 517 & Critical Branch in Code 517.
3. Review how the equipment systems shall be installed - Reference Code 517.
4. Discuss wiring and equipment within hazardous areas in health care facilities, such as inhalation anesthetizing locations, etc.
5. Explain general wiring, sources of power, and installation and maintenance of equipment in Emergency Systems.
6. Discuss the installation, operation, and maintenance of circuits, systems, and equipment intended to supply on-site generated power (to selected loads, automatically or manually, in the event of failure of the normal source of electrical service).

APPLICATION AND CHECK-UP:

The students should complete the questions on the worksheet. They should be checked, corrected, and filed in the notebooks.

Motor enclosures

(NEMA designations)*

OPEN

General purpose: Ventilating openings permit passage of external cooling air over and around the windings of the machine.

Drip-proof: Ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle from 0 to 15 degrees downward from the vertical.

Splash-proof: Ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle not greater than 100 degrees downward from the vertical.

Guarded: Openings giving direct access to live or rotating parts (except smooth shafts) are limited as to size by the design of the structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with such parts.

Semi-guarded: Part of the ventilating openings, usually in top half, are guarded as in a "guarded machine," but others are left open.

Drip-proof fully guarded: A drip-proof machine with ventilating openings as in a "guarded machine."

Externally ventilated: A machine which is ventilated by means of a separate motor-driven blower mounted on machine enclosure. Mechanical protection may be as defined above.

Pipe ventilated: Openings for admission of ventilating air are so arranged that inlet ducts or pipes can be connected to them.

Weather-protected: Type I: Ventilation passages are so designed as to minimize the entrance of rain, snow and airborne particles to the electrical parts. Type II: Ventilating passages at intake and discharge are so arranged that high-velocity air and airborne particles blown into the machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electrical parts.

Encapsulated windings: An alternating-current squirrel-cage machine having random windings filled with an insulating resin which also forms a protective coating.

Sealed windings: An alternating-current squirrel-cage machine making use of form-wound coils and having an insulation system which, through the use of materials, processes, or a combination of materials and processes, results in a sealing of the windings and connections against contaminants.

TOTALLY ENCLOSED

Nonventilated: Enclosure prevents free exchange of air between inside and outside of case, but not airtight.

Fan-cooled: Equipped for exterior cooling by means of a fan or fans, integral with machine, but external to the enclosing parts.

Fan-cooled guarded: All openings, giving direct access to fan, are limited in size by design of structural parts or by screens, grills, expanded metal, etc., to prevent accidental contact with fan.

Explosion-proof: Designed and built to withstand an explosion of gas or vapor within it and to prevent ignition of gas or vapor surrounding machine by sparks, flashes, or explosions which may occur within machine casing.

Dust-ignition-proof: Designed and built to exclude ignitable amounts of dust or amounts affecting performance or rating to prevent ignition of exterior dust on or in vicinity of enclosure.

Water-proof: Designed to exclude water applied in a stream from a hose except leakage is permitted around the shaft provided that water is excluded from oil reservoir and means of drainage is provided.

Pipe-ventilated: Openings so arranged that inlet and outlet ducts or pipes may be connected to them for the admission and discharge of ventilating air.

Water-cooled: Cooled by circulating water; the water or water conductors come in direct contact with the machine parts.

Water-air-cooled: Cooled by circulating air which, in turn, is cooled by circulating water.

Air-to-air-cooled: Cooled by circulating internal air through heat exchanger which, in turn, is cooled by circulating external air.

See NEMA Standards MG1-1.25,26,27 for additional details.

Basic motor insulation classes

Class A. Materials or combinations of materials such as cotton, silk and paper, when suitably impregnated or coated, or when immersed in a dielectric liquid such as oil. This class of material is falling into disuse.

Class B. Materials or combinations of materials such as mica, glass fiber, asbestos, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests the total system can be shown to be capable of operating successfully on the machine under consideration (120°F-130°F).

Class F. Materials or combinations of materials such as mica, glass fiber, asbestos, etc., with suitable bonding substances. Other materials or combinations of materials, not necessarily inorganic, may be included in this class if by experience or accepted tests the total system can be shown to be capable of operating successfully on the machine under consideration (145°F-155°F).

Class H. Materials or combinations of materials such as silicone elastomer, mica, glass fiber, asbestos, etc., with suitable bonding substances such as appropriate silicone resins. Other materials or combinations of materials may be included in this class if by experience or accepted tests the total system can be shown to be capable of operating successfully on the machine under consideration (165°F-180°F).

Controller enclosures

(NEMA designations)*

Type	Description	Application
1	General purpose	Indoors; atmospheric conditions normal. Provides protection against dust and light, indirect splashing—but is not dust-tight.
2	Driptight	Indoors; general-purpose enclosure; shields give protection from dripping liquids and dirt.
3	Weather-resistant (Weatherproof)	Outdoors; where exposed to rain or sleet.
4	Watertight	Outdoors; water or moisture excluded from splashing or direct stream.
5	Dust-tight	Indoors: prevents entry of dust into nonhazardous locations.
6	Submersible	For use where unit may be submerged in water.
7	Hazardous areas (Groups A-B-C-D)	For Class 1 locations containing hazardous gases; air-break contacts.
8	Hazardous areas (Groups A-B-C-D)	For use where gases are corrosive (similar to Type 7, but contacts are immersed in oil).
9	Hazardous areas (Groups E-F-G)	For use in Class II, Group E, F and G locations containing hazardous dusts.
10	Bureau of Mines	For use in coal mines.
11	Corrosion-proof	For use where exposed to corrosive acid or fumes.
12	Industrial	Protects against dirt, dust, lint, fibers, flyings and oil or coolant seepage; meets JIC electrical standards for industrial equipment.

* Last revised in 1968.

NAME ______________________ LESSON B-17

DATE ______________________ WORKSHEET

D.C. MOTORS AND GENERATORS

1 What are the three principal types of D.C. motors?

a. SHUNT-WOUND

b. SERIES-WOUND

c. COMPOUND-WOUND

2. The reostat LIMITS the flow of current in starting a D.C. motor.

3. The speed of D.C. motors can be controlled by what two general classifications?

a. ARMATURE CONTROL

b. FIELD CONTROL

4. There are two types of electrodynamic drive control for D.C. motors. Name them.

a. AMPLIDYNE

b. ROTOTROL (ALSO CALLED SERVO SYSTEM)

5. The actual effective voltage in an armature of a D.C. motor is the APPLIED voltage less the COUNTER-EMF.

6. The speed of a D.C. motor depends on:

a. STRENGTH OF MAGNETIC FIELD

b. VALUE OF APPLIED VOLTAGE

c. LOAD

7. Shunt motors are considered as CONSTANT speed motors.

8. Series motors are considered as VARIABLE speed motors.

9. The compound motor is a combination of the SHUNT motor and the SERIES motor.

10. The direction of rotation of a D.C. motor can be reversed by reversing the FIELD connections or the ARMATURE connections.

11. A DIVERTER - POLE generator is used to charge batteries by the floating method of charge because it can produce a constant terminal VOLTAGE of from 0-110%.

12. To generate electricity, there must be a relative motion between a CONDUCTOR and a MAGNETIC field.

13. In D. C. generators, the armature is always the ROTOR. In most A. C. generators, the armature is STATIONARY.

14. A. C. generators are sometimes called ALTERNATORS.

15. A three-phase alternator has each phase displaced 120 degrees from each other.

16. In a 3 Ø "wye" or "star" alternator, the line voltage across any two line levels is the VECTOR SUM of the individual phase voltages. The line voltage is 1.73 times the phase voltage. Line and phase currents are EQUAL.

17. In a 3 Ø "delta" alternator, the line voltages are EQUAL to the phase voltage, but the line currents will be equal to the VECTOR SUM of the phase currents. The line current will be 1.73 times the phase current.

SINGLE-PHASE MOTORS

DESIRED RESULTS:

To acquaint the students with the single-phase motor, how and why it operates, and its proper use on the job.

MATERIALS:

1. Sample motors
2. Film - "Motor Principles". United World Films or General Electric Co., Schenectady 5, N. Y.

INTRODUCTION:

When it was discovered that a coil of wire induces magnetic polarity in a soft-iron core, studies were made to find out that the poles were induced into the rotor. It was discovered that two sets of poles are so induced, one by transformer action and one by the generating action of cutting lines of force. The poles induced by transformer action were found to be the most essential to successful operation of the motor. A pole induced in the rotor through transformer action becomes active only after it has rotated far enough to be attracted toward the next stator pole ahead. This delayed action was found to be caused by the fact that induced voltages lag, inducing fluxes by 90 degrees, and that current flow in a highly inductive circuit, as exists in the rotor, lags the voltage by 90 degrees.

The capacitor motor plays such an important part in the work of an electrician today that it cannot be slighted. You will be working with this motor almost daily as an electrician, so be sure to know how and why it runs. It is easy to get confused because of the different classes of capacitor motors. Learn to recognize the several classes of capacitor-start split-phase induction motors.

The repulsion motor is not nearly as popular as it was before the introduction of capacitor-start motor. Although they are being replaced in many installations today, there are a great number still in service on air compressors and other heavy starting load applications. The electrician should be familiar with this motor and its characteristics.

This lesson begins a series of studies of fractional horsepower motors. These motors are named from their differences in methods of starting. One type of induction motor which incorporates a starting device is called a "split-phase" induction motor. This motor uses combinations of inductance, capacitance and resistance to develop a rotating field. Split-phase motors come only in small sizes because special starting windings are very light, thus the motor does not develop enough torque to start heavy loads. Remember that this type of motor is very common and you will contact it most frequently in your work.

PRESENTING THE LESSON:

1. The first type of split-phase induction motor that we will study is the capacitor-start model. Refer to the simplified schematic diagrams in your texts for a typical capacitor-start motor. There are two windings, the main winding and a starting winding which is connected in parallel with the main winding and spaced at right angles to it. The 90 degree electrical phase difference between the two windings is obtained by connecting the auxiliary winding in series with a capacitor and the starting switch. Upon starting, the switch is closed, placing the capacitor in series with the auxiliary winding. The capacitor is of such a value that the auxiliary winding is effectively a resistive-capacitive circuit in which the current leads the live voltage by approximately 45 degrees. The main winding has enough resistance to cause the current to lag the line voltage by approximately 45 degrees. The two currents are therefore 90 degrees out of phase and so are the magnetic fields which they generate. The effect is that the two windings act like a two-phase stator and produce the revolving field required to start the motor.

2. Demonstrate the sample motors to the class and be sure that the students understand how they run. The student should be able to determine whether or not a motor should be sent to a shop, be replaced, or repaired on the job.

3. The student should obtain a clear picture of the rotating magnetic field. He should be familiar with the relationships between voltage and torque, and starting, running, and breakdown torques in the induction motor.

4. Show the film -"Motor Principles".

5. Discuss items brought out by the film or any questions that arise from the students.

APPLICATION:

Give the students time to complete the assignment sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and discuss any questions the students will ask concerning split-phase motors.

NAME ______________________________ LESSON B-18

DATE ______________________________ WORKSHEET

SINGLE PHASE MOTORS

1. The starting WINDING has a HIGHER resistance than the running winding of a split-phase motor, thus the interaction of the rotating magnetic field provides a starting TORQUE for the motor.

2. The purpose of the STARTING WINDING is to get a PHASE DISPLACEMENT between the windings.

3. The angular phase displacement in a split-phase motor is approximately 45 to 30 degrees in time.

4. The CENTRIFUGAL SWITCH opens the circuit to the starting winding as the rotor speed reaches approximately 50-80 percent of the synchronous speed.

5. Overheating of the winding insulation may be caused by LOW VOLTAGE, DAMP WINDINGS, and TOO HEAVY currents.

6. The standard direction of rotation is CLOCKWISE as viewed from the PULLEY END.

7. Two-speed split-phase motors have TWO sets of windings, ONE SET for each speed.

8. The permanent-split capacitor motor has a LOW STARTING torque.

9. There is no change in CONNECTION in the permanent-split capacitor motor.

10. Permanent SPLIT CAPACITOR motors are used for fans and blowers.

11. Repulsion motors have a very HIGH torque.

12. As the load increases in the repulsion motor, the TORQUE decreases.

13. Repulsion motors may be reversed by shifting BRUSHES to the OPPOSITE side of neutral plane.

14. In a repulsion motor, the STATOR poles are repelled by the ROTOR poles causing the ROTOR to rotate.

15. The SERIES (UNIVERSAL) motor operates on A.C. or D.C. circuits.

16. The ARMATURE is connected in series with the FIELD in a universal motor.

17. In a universal motor operating on an A.C. source, the ___FIELD___ windings are arranged so the ___POLARITY___ of the magnetic poles changes causing the ___ARMATURE___ to turn.

18. List two types of universal motors:

(a) ___COMPENSATED___

(b) ___NON-COMPENSATED___

19. The ___COMPENSATED___ universal motor has an extra winding embedded in the poles of the starter.

20. The ___COMPENSATED___ universal motor is a low-horsepower motor operating at ___MODERATE___ speeds.

21. A ___RESISTOR___ must be installed in series with one of the power lines to the concentrated-pole universal motor at speeds less than ___3500___ RPM.

22. List three methods used to control the no-load speeds of the universal motor:

(a) ___VARIABLE RESISTOR PARALLEL WITH ARMATURE___

(b) ___GOVERNOR IN SERIES WITH FIELD WINDING___

(c) ___CAPACITOR-RESISTOR PARALLEL COMBINATION IN SERIES WITH LINE___

THREE-PHASE MOTORS

DESIRED RESULTS:

1. To review the principle of the rotating magnetic field in order to understand the three-phase motor.

2. The student should know how the motor runs and how to connect and service it.

MATERIALS AND SUPPLIES:

1. Chalkboard
2. Three-phase cut-away
3. Disassembled squirrel-cage motor
4. Film - "Squirrel-Cage Rotor Principles"

INTRODUCTION:

Three-phase systems are widely used because they are superior to single-phase systems in many ways. These motors are smaller, simpler in construction, and have better operating characteristics than the single phase units of the same capacity. You should learn the basic ideas of the three-phase motors well in order to know what to do on the job. Since the three-phase motor is the workhorse of industry today, it is important that the apprentice knows how it runs and how to connect and service it.

PRESENTING THE LESSON:

Show the film - "Squirrel-Cage Rotor Principles" or equivalent

1. Review the principle of the rotating magnetic field.
2. Discuss the general types of three-phase motors in common usage.
3. Show how the three-phase windings of a motor are placed, spaced, and connected.
4. Show the class the standard lead connections for squirrel-cage motors. Be sure that they learn these connections.
5. What can be noted about the speed of a squirrel-cage motor under varying loads?
6. Note that the direction of rotation of an induction motor is the same as that of the magnetic field.
7. Show how a three-phase motor can be reversed.
8. What is the starting torque of a pure synchronous motor?
9. How do you control the speed of a wound-rotor motor?

10. Explain the formula for finding the percent of slip of an induction motor:

$$\text{Percent of slip} = \frac{\text{Synchronous speed} - \text{operating speed} \times 100}{\text{Synchronous Speed}}$$

APPLICATION:

Have the students complete the questions on the Assignment Sheet.

CHECKING AND FOLLOW-UP:

Check the answers and discuss any noticeable mistakes made by the students.

NAME ____________________ LESSON B-19

DATE ____________________ WORKSHEET

THREE PHASE MOTORS

1. List the three major types of three-phase motors:

   (a) STRAIGHT INDUCTION

   (b) WOUND ROTOR-VARIABLE SPEED

   (c) SYNCHRONOUS (HAVING SEPARATELY EXCITED FIELD)

2. Squirrel-cage motors do not have a HIGH STARTING torque.

3. In a three-phase motor, the windings are 120 electrical degrees apart.

4. List two methods of connecting a three-phase motor stator to a three phase power source.

   (a) DELTA Δ

   (b) WYE Y

5. The SQUIRREL - CAGE motor operates on the induction principle.

6. The squirrel-cage motor never reaches SYNCHRONOUS speed.

7. List the four conditions which regulate the speed of a squirrel-cage motor:

   (a) AIR GAP

   (b) FREQUENCY

   (c) NUMBER OF POLES IN WINDING

   (d) LOAD ON MOTOR

8. The difference between the speed of the rotating field and the rotor is called SLIP.

9. The squirrel-cage motor is considered to be a STRAIGHT - INDUCTION type.

10. The currents produced in the rotor are fed to EXTERNAL RESISTORS of a wound-rotor motor.

11. In a wound-rotor motor, the starting SPEED and current, FULL load and TORQUE of the motor can be controlled.

12. In a wound-rotor motor, loss of speed results in a LOSS of TORQUE.

13. The wound-rotor motor is used for equipment having constant TORQUE LOADS and INCREASING HORSEPOWER up to full-rated load.

14. The rotation of a three-phase motor may be reversed by REVERSING any TWO LEADS to the motor.

15. The two windings of three-phase induction motors are located in the STATOR and ROTOR.

16. The ROTOR windings are embedded in slots.

17. The rotor windings may be of the WOUND - ROTOR or SQUIRREL - CAGE type.

18. List two important characteristics of a synchronous motor:

    (a) POWER FACTOR CORRECTION

    (b) CONSTANT SPEED

19. What are the four main types of electric motor braking?

    (a) FRICTION BRAKING

    (b) PLUGGING

    (c) DYNAMIC BRAKING

    (d) REGENERATIVE BRAKING

20. What type motor is used to transmit information in the form of electrical signals? SYNCHRONOUS MOTOR OR "SERVO" MOTORS

MOTOR CIRCUITS

DESIRED RESULTS:

To acquaint the student with the N.E. Code requirements in regard to motors and their installation.

INTRODUCTION:

The Code places great importance upon the proper installation of this equipment, even to the point of devoting a lengthy section to motors. Be sure that the student understands the requirements of Article 430 and how they apply on the job.

PRESENTING THE LESSON:

The students should read the reference article and class discussion should cover those sections of Article 430 not specifically touched upon by the questions on the Assignment Sheet. The student can usually answer some of the questions from general knowledge or guessing. However, if he is required to list the section number after his answer, he will read and learn more Code in studying the lesson.

APPLICATION:

Have the students look up the answers to the questions and list the section number after each.

CHECKING AND FOLLOW-UP:

Check the answers with the students and return the papers for placing in the notebooks. Continue the study of Motor Circuits.

NOTE: The next lesson, B-21, consists of a work session using the problem and diagram given in the Student's Worksheets.

NAME ______________________________ LESSON B-20

DATE ______________________________ WORKSHEET

MOTOR CIRCUITS

1. Explain what the N. E. Code means when it specifies that some equipment shall be "in sight from" another equipment.

EQUIPMENT MUST BE VISIBLE AND NOT MORE THAN 50 FEET DISTANCE.

430-4

2. List the information that should be on the name plate of a motor.

1. MAKER'S NAME
2. RATE VOLTS AND FULL LOAD AMPERES
3. RATED FREQUENCY, NUMBER OF PHASES, IF AC OR DC CURRENT
4. RATED SPEED (430-7 "A" "B" & "C" "D")
5. RATED TEMPERATURE
6. TIME RATING
7. RATED HORSEPOWER
8. CODE LETTER
9. SECONDARY VOLTAGE IF A WOUND-ROTOR INDUCTION MOTOR
10. WINDING

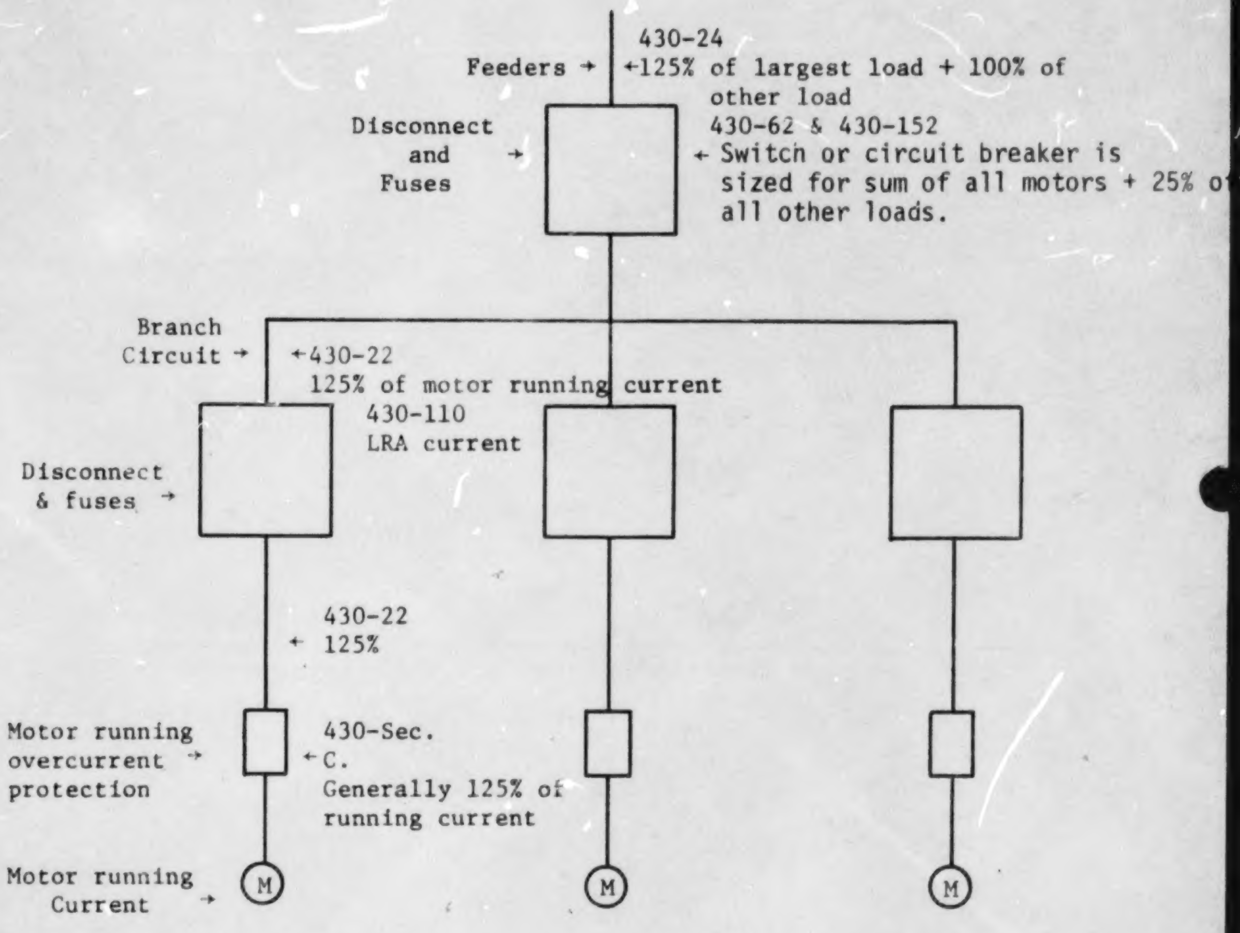
3. What are the three types of motor circuit conductors? Give the N.E. Code Section for each type.

	Types	Code Section
a.	CIRCUITS SUPPLYING SINGLE MOTORS	430-22
b.	CONDUCTORS SUPPLYING SEVERAL MOTORS	430-24
c.	CONDUCTORS SUPPLYING A COMBINATION LOAD	430-25

4. Draw a one line Schematic Diagram showing three motors connected. Show all disconnects, feeders, branch circuits, and overcurrent protection. Give the N. E. Code Section for each provision. Show or list the Branch Circuits located less than 25 feet from main.

(Space for answer on next page.)

4. (Answer)


430-24
Feeders →
←125% of largest load + 100% of other load
Disconnect and Fuses →
430-62 & 430-152
← Switch or circuit breaker is sized for sum of all motors + 25% o
all other loads.
Branch Circuit →
←430-22
125% of motor running current
430-110
LRA current
Disconnect & fuses →
430-22
← 125%
Motor running overcurrent protection →
430-Sec.
← C.
Generally 125% of running current
Motor running Current →
M
M
M

5. Match the Code Section by placing the capital letters from the Code Numbers in front of the lower case letters representing the Code Statements.

STATEMENTS

G a. Motor terminals shall be marked

E b. Motor circuit conductors shall have current carrying capacity of 125 percent of full load current

A c. Motor controller and disconnects shall not be used as junction boxes for feed through conductors

H & D d. Circuit overcurrent devices must open each ungrounded conductor

F e. Branch-circuit overcurrent device is a suitable controller for a stationary motor rated at 1/8 horsepower or less

C f. The disconnecting means shall disconnect the motor and the controller from all ungrounded supply conductors

B g. Plug and receptacle is a suitable controller for a portable motor rated at 1/3 horsepower or less

CODE SECTION

A. 430-10

B. 430-81 (c)

C. 430-103

D. 430-56

E. 430-22

F. 430-81 (b)

G. 430-9

H. 240-20 (b)

MOTOR CIRCUIT CALCULATIONS

DESIRED RESULTS:

To acquaint the student with the N. E. Code requirements in regard to motors and their installation.

INTRODUCTION:

The Code places great importance upon the proper installation of this equipment, even to the point of devoting a lengthy section to motors. Be sure that the student understands the requirements of Article 430 and how they apply on the job.

PRESENTING THE LESSON:

The students should read the reference article and class discussion should cover those sections of Article 430 not specifically touched upon by the questions on the Assignment Sheet. The student can usually answer some of the questions from general knowledge or guessing. However, if he is required to list the section number after his answer, he will read and learn more Code in studying the lesson.

APPLICATION:

Have the students look up the answers to the questions and list the section number after each.

CHECKING AND FOLLOW-UP:

Check the answers with the students and return the papers for placing in the notebooks. Continue the study of Motor Circuits.

NOTE: This lesson consists of a work session using the problem and diagram given in the Student's Worksheets.

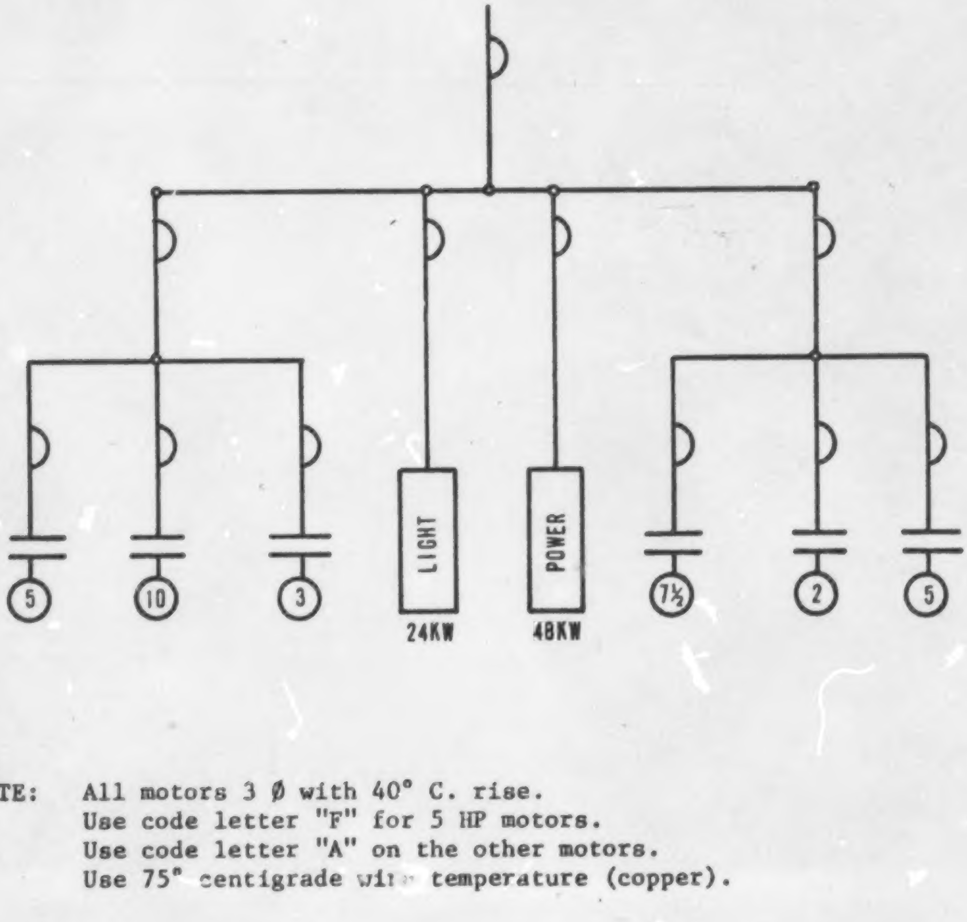
NAME ______________________________ LESSON B-21

DATE ______________________________ WORKSHEET

MOTOR CIRCUIT CALCULATIONS

PROBLEM: Using the National Electrical Code as reference, find the following for the electrical system below rated 120/208 volts, three phase, four wire:

a. Minimum feeder size
b. Maximum feeder overcurrent protection
c. Minimum branch circuit conductors
d. Maximum branch circuit overcurrent protection
e. Maximum motor-running overcurrent protection



NOTE: All motors 3 0 with 40° C. rise.
Use code letter "F" for 5 HP motors.
Use code letter "A" on the other motors.
Use 75° centigrade wire temperature (copper).

ANSWER SHEET LESSON B-21

1. a. Motor # 1 5 HP
   1. Running current 430-150 15.2 + 10% = 16.7 or 17
   2. Running overcurrent 430-32 125% of running current. 16.7 + 4.1=20.8 or 21 amps
   3. Branch circuit - 430-22 17 + 25% = 17 + 4 = 21 amps - #10 AWG
   4. Fuses 430-152 300% = 17 x 3 = 51 = 50 amp 240-4 (b)
   5. Disconnect - 60 amp

   b. Motor # 2 10 HP
   1. Running current 430-150 28 + 10% = 30.8 or 31 amps
   2. Running overcurrent 430-32. 30.8 + 25% = 30.8 + 7.7 = 38.5 amps #8 AWG
   3. Branch circuit - 430-22 31 + 25% = 31 + 7.75 = 39 amps
   4. Fuses - 430-152 150% 1.5 x 31 = 46.5 240-4 (b) 50 Amp fuses
   5. Disconnect 100 Amp

   c. Motor # 3
   1. Running current 430-150 9.6 + 10% = 10.5 or 11 Amps
   2. Running overcurrent 430-32 11 + 25% = 11 + 2.7 = 13.7 Amps
   3. Branch circuit 430-22 11 + 25% = 11 + 2.75 = 14 Amps # 14 AWG
   4. Fuses - 430-152 - 150 11 x1.5= 16.5 Amps 20 fuses
   5. Disconnect 30 Amp. Under normal conditions 20 Amp Fuse and,30A disconnect would be sufficient.

2. Lights
   1. Branch circuit 2400 ÷ 360 = 66.6 or 67 Amps # 4 AWG (4 conductors)
   2. Fuses 240-4 (b) 70 Amp
   3. Disconnect 100 Amp

3. Power
   1. Branch circuit 48 kW ÷ 360 = 133 Amps + 25% for continuous duty.
   2. Fuses 150 Amp
   3. Disconnect 200 Amp

4. a. Motor # 4 7 1/2 HP
   1. Running current 430-150 22 + 10% = 24 Amps
   2. Running overcurrent 430-32 24 + 25% = 24 + 6 = 30 amps
   3. Branch circuit 430-22 24 + 25% = 24+6 = 30 Amps # 10 AWG
   4. Fuses - 430-152 1.50 x 24 = 36 Amps 40A Fuse - 60A Switch
   5. Disconnect 100 Amp

   b. Motor # 5 2 HP
   1. Running current 430-150 - 6.8 + 10% = 6.8 + .6 = 7.4 or 8 Amps
   2. Running overcurrent 430-32 = 8 + 25% = 8 + 2 = 10 Amps
   3. Branch circuit 430-22 8 + 25% = 8 + 2 = 10 Amps #14 AWG
   4. Fuses 430-152 1.5 x 8 = 12A or 15A Fuse - 30A Switch
   5. Disconnect 30 Amp

c. Motor # 6 5 HP

1. Running current 430-150 15.2 + 10% = 16.7 or 17 Amps
2. Running overcurrent 430-32 - 16.7 + 4.1 = 21 Amps
3. Branch circuit 430-22 17 + 25% = 17 + 4 = 21 amps #12? or 10 AWG
4. Fuses 430-152 - 300% = 17 x 3 = 51 Amps 50 Amp fuses
5. Disconnect 60 Amp

5. Motors 1, 2, & 3

a. Fuses 430-53 (c-4) 430-152 50A Fuse + 28A + 9.6A = 87.6A or 80A Fuse

b. Disconnect - 100A

c. Branch circuit 430-54 100% of all load + 25% of largest motor load.
17 + 31 + 11 = 59 + 25% of 31 = 59 + 8 = 67 Amps # 4 AWG

6. Motors 4, 5, & 6

a. Fuses 430-53 (c-4) 430-152 50 A Fuse + 8A + 24 A = 82A, or 80A Fus
80 - 100 A Switch

b. Disconnect 100 Amp

c. Branch circuit 430-24 17 + 10 + (24 + 25%) = 27 + 30 = 57 Amps
# 6 AWG

7. Total combined load

	Feeders 430-25
Motor	1. 17.0
	2. 31.0
	3. 11.0
Lights	67.0
Power	133.0
Motor	4. 24.0
	5. 8.0
	6. 17.0
25% of Motor #2	8
	316.0 Amps
	400 MCM Feeders

Main Line Fuses
For 5HP Motor - 50A Fuse
+ 31A = 10HP
+ 11A = 3HP
+ 67A = Lts
+ 133A= Power
+ 24A = 7½HP Motor
+ 8A = 2HP
+ 17A = Other 5HP
341A or 300A Fuse
See 430-62(Says--
Not Greater, etc)

Main Disconnect
400 Amp

NAME ______________________________ LESSON B-22

DATE ______________________________ WORKSHEET

LIGHTING FIXTURES

1. Give three examples of "damp locations" which would require special construction:

   a. BASEMENTS
   b. BARNS
   c. COLD STORAGE WAREHOUSES

   *ALTERNATE ANSWERS
   * UNDER CANOPIES
   * UNDER MARQUEES

2. Give three examples of "wet locations" which would require special consideration:

   a. SUBJECT TO SATURATION
   b. EXPOSED TO WEATHER
   c. INSTALLATIONS UNDERGROUND

   *ALTERNATE ANSWERS
   * VEHICLE WASHING AREAS
   * IN CONCRETE SLAB IN DIRECT CONTACT WITH EARTH

3. How shall the fixtures installed in a clothes closet be located?

   a. ON WALL ABOVE THE CLOSET DOOR (410-8)
   b. ON THE CEILING

4. What section of Article 410 lists the restrictions on closet fixture locations? 410-8 (A) & (B)

5. When is "feed-thru" wiring permitted in an outlet box which is an integral part of an incandescent fixture? WHEN THE FIXTURE IS APPROVED (LISTED) FOR "FEED-THRU" WIRING.

6. List the three requirements for a cord-connected electric discharge lighting fixture.

   a. CORD IS CONTINUOUSLY VISIBLE FOR ITS ENTIRE LENGTH
   b. CORD IS NOT SUBJECT TO STRAIN OR PHYSICAL DAMAGE
   c. CORD SHALL TERMINATE WITH A GROUNDING-TYPE PLUG

7. A fixture which weighs more than 6 pounds or exceeds 16 inches in any dimension shall not be supported by the screw-shell of a lampholder. (410-15)

8. A fixture which weighs more than 50 (410-16) pounds shall be supported independently of the outlet box.

9. What three factors determine the type of wire used in a fixture?

   a. INSULATED FOR THE VOLTAGE

   b. CAPABLE OF CARRYING THE CURRENT

   c. INSULATED FOR THE TEMPERATURE TO WHICH THE CONDUCTORS WILL BE SUBJECTED

10. On a screw-shell lampholder, where do the wires connect?

    a. Phase conductor connects to the BRASS screw.

    b. Identified conductor connects to the WHITE screw.

    c. The IDENTIFIED conductor must connect to the screw-shell terminal screw.

11. Branch circuit conductors within 3 inches of a ballast shall be recognized for use at temperatures not lower than 90 °C.

12. Four of the most used conductor types for fixture channel wiring are:

    a. RHH

    c. XHHW

    b. THHN

    d. THW

13. All wiring shall be free from short CIRCUITS and GROUNDS and shall be TESTED for these defects prior to being connected to the CIRCUIT.

14. N. E. Code Section 410-67C requires "a suitable metal raceway" for recessed fixtures. Is "flex" metal conduit approved? Yes/No YES. Give the N. E. Code Section to prove your answer. 350-4-EXC-3

15. Section 410-17 of the N. E. Code covers the grounding of fixtures and lighting equipment.

SWIMMING AND WADING POOLS

DESIRED RESULTS:

To study the Code requirements for installing electric wiring for equipment and lighting at swimming pools.

REFERENCES:

National Electrical Code, Article 680

INTRODUCTION:

The provisions of this Article apply to the construction and installation of electric wiring for equipment in or adjacent to swimming pools, and to the auxiliary equipment such as pumps, filters, and similar equipment. No electric wiring or apparatus shall be installed in the water or enclosed walls of a swimming pool, except as provided for in this article.

PRESENTING THE LESSON:

Have the students study this Article and look up any references. Discuss any questions that may arise, especially safety of certain pools. Present the definitions listed in 680-4 of this Article.

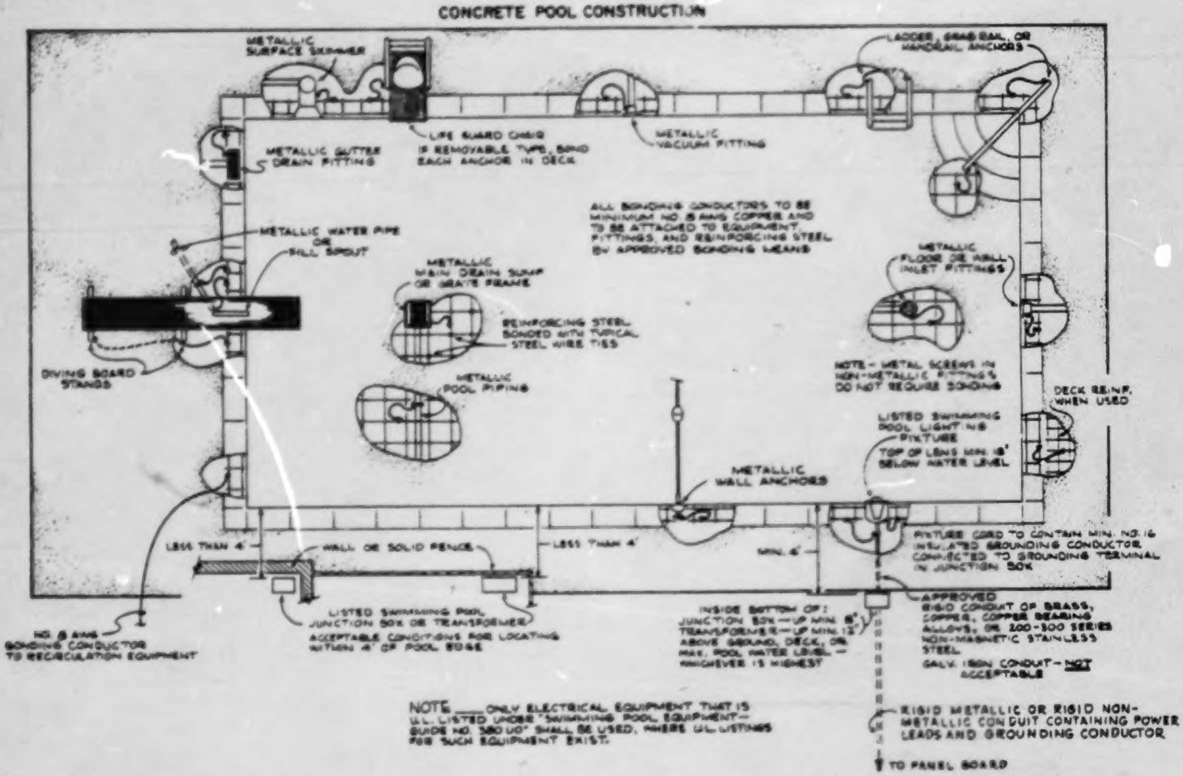
APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers to the questions and return the sheets to the students for correction.

SWIMMING POOL ELECTRICAL BONDING & GROUNDING



CONCRETE POOL CONSTRUCTION
METALLIC SURFACE SKIMMER
LIFE GUARD CHAIR IF REMOVABLE TYPE, BOND EACH ANCHOR IN DECK
METALLIC VACUUM FITTING
LADDER, GRAB RAIL, OR HANDRAIL ANCHORS
METALLIC GUTTER DRAIN FITTING
ALL BONDING CONDUCTORS TO BE MINIMUM NO. 8 AWG COPPER AND TO BE ATTACHED TO EQUIPMENT, FITTINGS, AND REINFORCING STEEL BY APPROVED BONDING MEANS
METALLIC WATER PIPE OR FILL SPOUT
METALLIC MAIN DRAIN SUMP OR GRATE FRAME
METALLIC FLOOR OR WALL INLET FITTINGS
REINFORCING STEEL BONDED WITH TYPICAL STEEL WIRE TIES
DIVING BOARD STANDS
METALLIC POOL PIPING
NOTE – METAL SCREWS IN NON-METALLIC FITTINGS DO NOT REQUIRE BONDING
DECK REINF. WHEN USED
LISTED SWIMMING POOL LIGHTING FIXTURE
TOP OF LENS MIN. 18" BELOW WATER LEVEL
METALLIC WALL ANCHORS
LESS THAN 4'
WALL OR SOLID FENCE
LESS THAN 4'
MIN. 4'
FIXTURE CORD TO CONTAIN MIN. NO. 16 INSULATED GROUNDING CONDUCTOR CONNECTED TO GROUNDING TERMINAL IN JUNCTION BOX
APPROVED RIGID CONDUIT OF BRASS, COPPER, COPPER BEARING ALLOYS, OR 200-300 SERIES NON-MAGNETIC STAINLESS STEEL
GALV. IRON CONDUIT – NOT ACCEPTABLE
LISTED SWIMMING POOL JUNCTION BOX OR TRANSFORMER
ACCEPTABLE CONDITIONS FOR LOCATING WITHIN 4' OF POOL EDGE
INSIDE BOTTOM OF: JUNCTION BOX—UP MIN. 8" TRANSFORMER—UP MIN. 12" ABOVE GROUND, DECK, OR MAX. POOL WATER LEVEL — WHICHEVER IS HIGHEST
NO. 8 AWG BONDING CONDUCTOR TO RECIRCULATION EQUIPMENT
RIGID METALLIC OR RIGID NON-METALLIC CONDUIT CONTAINING POWER LEADS AND GROUNDING CONDUCTOR
TO PANEL BOARD

NOTE ___ ONLY ELECTRICAL EQUIPMENT THAT IS U.L. LISTED UNDER "SWIMMING POOL EQUIPMENT—GUIDE NO. 380 UO" SHALL BE USED, WHERE U.L. LISTINGS FOR SUCH EQUIPMENT EXIST.

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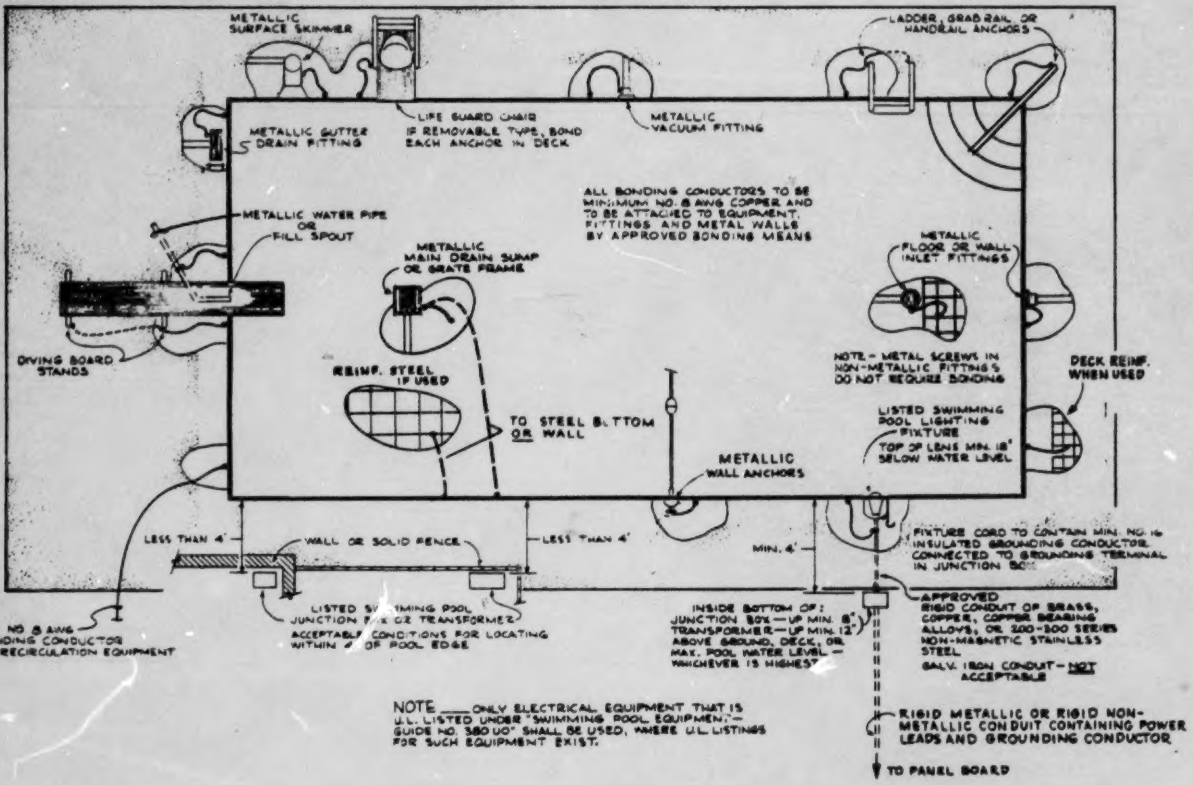
"ALL ELECTRICAL EQUIPMENT USED WITH SWIMMING AND WADING POOLS SHALL BE SUPPLIED BY CIRCUITS PROTECTED BY GROUND-FAULT CIRCUIT INTERRUPTERS."

SWIMMING POOL ELECTRICAL BONDING & GROUNDING

WELDED METAL POOL CONSTRUCTION


METALLIC SURFACE SKIMMER
LIFE GUARD CHAIR
IF REMOVABLE TYPE, BOND EACH ANCHOR IN DECK
METALLIC VACUUM FITTING
LADDER, GRAB RAIL OR HANDRAIL ANCHORS
METALLIC GUTTER DRAIN FITTING
METALLIC WATER PIPE OR FILL SPOUT
METALLIC MAIN DRAIN SUMP OR GRATE FRAME
DIVING BOARD STANDS
REINF. STEEL IF USED
TO STEEL BOTTOM OR WALL
METALLIC WALL ANCHORS
METALLIC FLOOR OR WALL INLET FITTINGS
DECK REINF. WHEN USED
LISTED SWIMMING POOL LIGHTING FIXTURE
TOP OF LENS MIN. 18" BELOW WATER LEVEL
LESS THAN 4'
WALL OR SOLID FENCE
LESS THAN 4'
MIN. 4'
LISTED SWIMMING POOL JUNCTION BOX OR TRANSFORMER
NO. 8 AWG BONDING CONDUCTOR TO RECIRCULATION EQUIPMENT
TO PANEL BOARD

ALL BONDING CONDUCTORS TO BE MINIMUM NO. 8 AWG COPPER AND TO BE ATTACHED TO EQUIPMENT, FITTINGS AND METAL WALLS BY APPROVED BONDING MEANS

NOTE – METAL SCREWS IN NON-METALLIC FITTINGS DO NOT REQUIRE BONDING

FIXTURE CORD TO CONTAIN MIN. NO. 16 INSULATED GROUNDING CONDUCTOR CONNECTED TO GROUNDING TERMINAL IN JUNCTION BOX

ACCEPTABLE CONDITIONS FOR LOCATING WITHIN 4' OF POOL EDGE

INSIDE BOTTOM OF:
JUNCTION BOX—UP MIN. 8"
TRANSFORMER—UP MIN. 12"
ABOVE GROUND, DECK, OR MAX. POOL WATER LEVEL — WHICHEVER IS HIGHEST

APPROVED RIGID CONDUIT OF BRASS, COPPER, COPPER BEARING ALLOYS, OR 200-300 SERIES NON-MAGNETIC STAINLESS STEEL

GALV. IRON CONDUIT—NOT ACCEPTABLE

RIGID METALLIC OR RIGID NON-METALLIC CONDUIT CONTAINING POWER LEADS AND GROUNDING CONDUCTOR

NOTE ___ ONLY ELECTRICAL EQUIPMENT THAT IS U.L. LISTED UNDER "SWIMMING POOL EQUIPMENT— GUIDE NO. 380 U0" SHALL BE USED, WHERE U.L. LISTINGS FOR SUCH EQUIPMENT EXIST.

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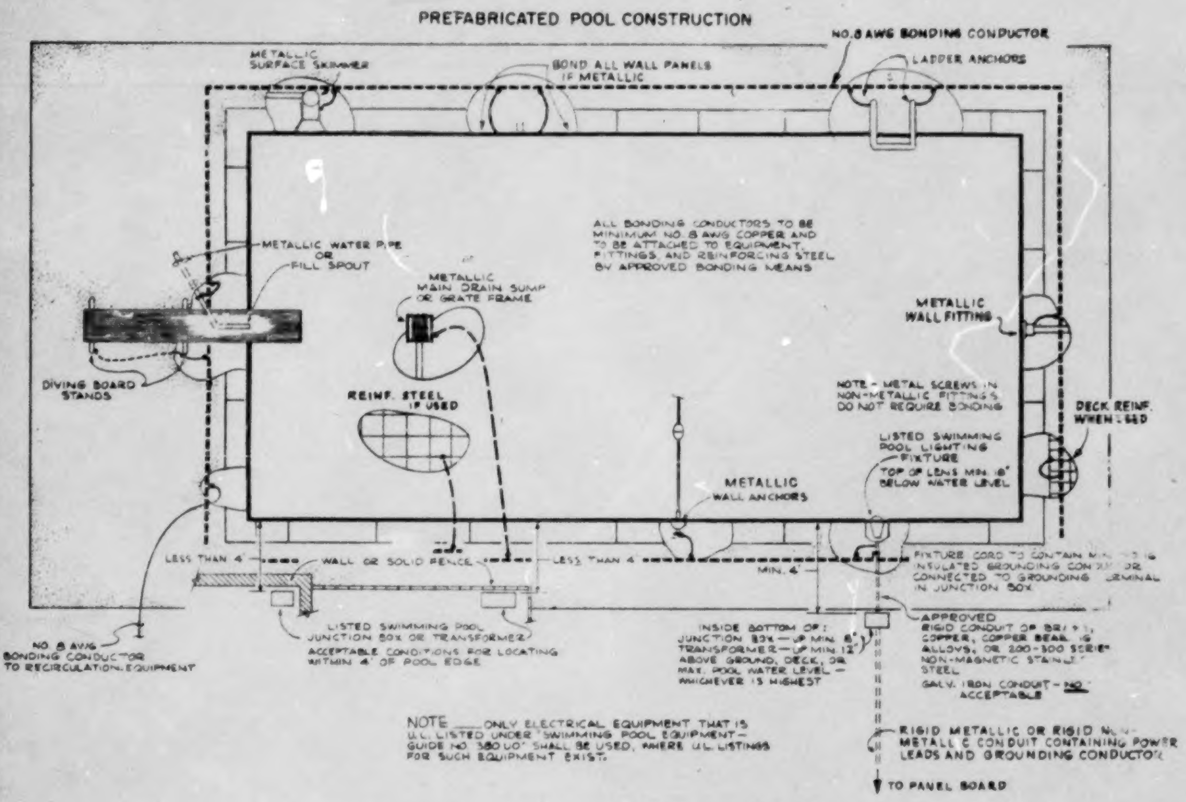
SWIMMING POOL ELECTRICAL BONDING & GROUNDING



PREFABRICATED POOL CONSTRUCTION

METALLIC SURFACE SKIMMER
BOND ALL WALL PANELS IF METALLIC
NO. 8 AWG BONDING CONDUCTOR
LADDER ANCHORS
METALLIC WATER PIPE OR FILL SPOUT
METALLIC MAIN DRAIN SUMP OR GRATE FRAME
DIVING BOARD STANDS
REINF. STEEL IF USED
METALLIC WALL FITTING
DECK REINF. WHEN USED
LISTED SWIMMING POOL LIGHTING FIXTURE
TOP OF LENS MIN. 18" BELOW WATER LEVEL
METALLIC WALL ANCHORS
LESS THAN 4'
WALL OR SOLID FENCE
LESS THAN 4'
MIN. 4'
NO. 8 AWG BONDING CONDUCTOR TO RECIRCULATION EQUIPMENT
LISTED SWIMMING POOL JUNCTION BOX OR TRANSFORMER
TO PANEL BOARD

ALL BONDING CONDUCTORS TO BE MINIMUM NO. 8 AWG COPPER AND TO BE ATTACHED TO EQUIPMENT, FITTINGS, AND REINFORCING STEEL BY APPROVED BONDING MEANS

NOTE – METAL SCREWS IN NON-METALLIC FITTINGS DO NOT REQUIRE BONDING

FIXTURE CORD TO CONTAIN MIN. NO. 16 INSULATED GROUNDING CONDUCTOR OR CONNECTED TO GROUNDING TERMINAL IN JUNCTION BOX

ACCEPTABLE CONDITIONS FOR LOCATING WITHIN 4' OF POOL EDGE

INSIDE BOTTOM OF:
JUNCTION BOX — UP MIN. 8"
TRANSFORMER — UP MIN. 12"
ABOVE GROUND, DECK, OR MAX. POOL WATER LEVEL — WHICHEVER IS HIGHEST

APPROVED RIGID CONDUIT OF BRASS, COPPER, COPPER BEARING ALLOYS, OR 200-300 SERIES NON-MAGNETIC STAINLESS STEEL

GALV. IRON CONDUIT – NOT ACCEPTABLE

RIGID METALLIC OR RIGID NON-METALLIC CONDUIT CONTAINING POWER LEADS AND GROUNDING CONDUCTOR

NOTE ___ ONLY ELECTRICAL EQUIPMENT THAT IS U.L. LISTED UNDER "SWIMMING POOL EQUIPMENT — GUIDE NO. 380 UO" SHALL BE USED, WHERE U.L. LISTINGS FOR SUCH EQUIPMENT EXIST.

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NAME ______________________ LESSON No. B-23

DATE ______________________ WORKSHEET

SWIMMING and WADING POOLS, and IRRIGATION MACHINES

1. All EQUIPMENT shall be approved for swimming pool installation.

2. Maximum voltage permitted for lighting fixtures is 150 volts.

3. All non-current-carrying metal parts of a lighting fixture shall be GROUNDED.

4. Service drop conductors shall not be installed above swimming pools or within 10 feet of inside walls of pool, DIVING structure, observation STANDS, towers or PLATFORMS.

5. Metal wiring enclosures shall be GROUNDED.

6. All pool equipment shall be GROUNDED to a common pool ground.

7. Metallic raceways shall not be depended upon for GROUNDING.

8. An INSULATED No. 12 minimum size conductor shall be installed from deck box to distribution panel ground.

9. Transformers used to supply fixtures shall meet the following requirements:

   a. APPROVED FOR THE LOCATION

   b. HAVE TWO WINDINGS WITH GROUNDED METAL BARRIER BETWEEN PRIMARY AND SECONDARY WINDINGS

10. How many grounding terminals are required in a junction box, transformer enclosure, or ground-fault circuit-interrupter? ONE MORE THAN THE NUMBER OF CONDUITS ENTERING THE ENCLOSURE.

11. Non-metallic conduit used to feed wet-niche fixtures requires an insulated No. 8 AWG solid COPPER grounding conductor.

12. Are all components of a pool water heater required to be grounded? NO. Give the N. E. Code section to justify your answer. 680-22 (C)

13. What seven specific items of equipment in a swimming pool are required to be grounded?

a. WET-NICHE UNDERWATER LIGHTING FIXTURES

b. DRY-NICHE UNDERWATER LIGHTING FIXTURES

c. ALL ELECTRICAL EQUIPMENT WITHIN 5 FT. OF INSIDE WALL OF POOL

d. JUNCTION BOXES

e. TRANSFORMER ENCLOSURES

f. PANELBOARDS SERVICING POOL EQUIPMENT IF NOT PART OF SERVICE EQUIPMENT

g. ALL ELECTRICAL EQUIPMENT ASSOCIATED WITH RECIRCULATING SYSTEM OF THE POOL

14. The filter pump of a storable pool is required to have double insulation and be effectively grounded. What other protective device is also required? GROUND-FAULT CIRCUIT INTERRUPTER

15. Grounds-Fault circuit interrupte' are not required on existing lighting fixtures and lighting outlets located less than five feet from pool walls. True/[✓ False] Give code section. (680-6 (B)

16. Are special provisions made for lightning protection if an irrigation machine has a stationary point? [✓ Yes]/No Give code section for answer. (675-11)

17. What purposes does collector rings serve on irrigation machine? THEY ARE AN ASSEMBLY OF SLIP RINGS FOR TRANSFERRING ELECTRICAL ENERGY FROM A STATIONARY POINT TO A ROTATING MEMBER (675-2)

CRANES, HOISTS, ELEVATORS, DUMBWAITERS, AND ESCALATORS

DESIRED RESULTS:

To study the Code requirements for electrical equipment and wiring used in connection with elevators, dumbwaiters, escalators, and moving walks.

REFERENCES:

National Electrical Code, Articles 610 and 620

INTRODUCTION:

The provisions of this article apply to electrical equipment and wiring used in connection with elevators, dumbwaiters, escalators, etc. They will also apply to console lifts, equipment for raising and lowering or rotating portions of theater stages, and all similar equipment.

All wiring in the raceways and in or on the cars of elevators, etc. shall be flame-retardant and moisture-resistant insulation. The thickness of the insulation of all wiring shall be suitable for the voltage to which the wiring is subjected.

NOTE: A distinction is made here between the heavy connections carrying the power current and the smaller wires of operating circuits, such as wire connected to the magnet coils of contactors. The operating current passing thorugh the magnet coils may be quite small and a small current leaking through damp slow-burning insulation where two insulated wires are in contact might be sufficient to operate a contactor.

PRESENTING THE LESSON:

Have the students review Articles 610 and 620 and then study them in detail. They should note the minimum size of conductors and their installation, and the different systems in one raceway or cable and the requirements for this installation. The requirements for motor circuit conductors should be discussed.

Disconnecting means, overcurrent protection, grounding, and overspeed control should be provided.

A machine room shall be provided to secure all moving motor generator sets, driving machines, controllers, and auxiliary control equipment.

APPLICATION:

Have the students complete the questions on the Assignment Sheet using the Code book.

CHECKING AND FOLLOW-UP:

Check the answers and return to the students for correction and placing in their notebooks.

NAME ______________________________ LESSON No. B-24

DATE ______________________________ WORKSHEET

CRANES, HOISTS, ELEVATORS, DUMBWAITERS, AND ESCALATORS

1. The five major items of equipment for crane power are:

   a. COLLECTOR SWITCH
   b. COLLECTOR CONTACT CONDUCTORS FOR MAIN
   c. CAB MAIN-LINE SWITCH
   d. COLLECTOR CONTACT CONDUCTORS FOR BRIDGE
   e. MOTOR CIRCUIT WIRING

2. What is the main difference in the various types of lifting and moving equipment covered in this assignment? CRANES AND MONORAILS GENERALLY TRAVEL ON AN ELECTRIFIED TRACK OR TAKE THEIR POWER FROM BUS BARS OR CONDUCTORS, HOISTS, ELEVATORS, DUMBWAITERS, ESCALATORS, AND MOVING WALKS ARE DRIVEN FROM A FIXED MOTOR.

3. The maximum voltage permitted on A.C. system for control and signal circuits is 300 volts except where the maximum current is 8 MILLIAMPERES.

4. The maximum voltage permitted for machine motors is 600 volts.

5. Travel cables shall be Type E, EO, or EN.

6. Type THW conductor is suitable for installation in raceways on an elevator.

7. The minimum gauge traveling conductor permitted for lighting circuit is No. 20 AWG in parallel.

8. In general, conductors located in hoistway shall be installed in METAL raceways.

9. Raceway shall terminate a minimum of 6 inches above the floor.

10. Conduits installed in hoistway shall be securely fastened to the GUIDE RAIL or HOISTWAY construction.

11. Conductors of different systems may be installed in the same conduit provided all the conductors are insulated for the MAXIMUM VOLTAGE.

12. Main feeder supply power to the elevator shall be installed OUTSIDE the hoistway.

13. No FOREIGN conduits or wires shall be installed in the hoistway.

14. A DISCONNECTING means shall be provided at the elevator machine for disconnecting all circuit conductors to the elevator motor.

15. Wiring and equipment located under the car platform of a garage elevator shall be considered in a HAZARDOUS location.

16. Elevator equipment shall be installed in an area secured against UNAUTHORIZED access.

17. A minimum working space of 24 inches shall be provided in the rear of an elevator control panel.

18. Electric elevator machines shall be GROUNDED.

EMERGENCY SYSTEMS

DESIRED RESULTS:

1. To study the reasons for providing separate power and light emergency systems in places of assembly.
2. To acquaint the student with the requirements of the National Electrical Code that apply to emergency systems.

REFERENCES:

1. National Electrical Code, Article 700
2. Information Sheets (attached)

INTRODUCTION AND PRESENTATION:

Emergency systems are generally installed in places of assembly where artificial illumination is required, such as buildings subject to occupancy by large numbers of persons, hotels, theaters, sports arenas, hospitals, and similar institutions. Storage batteries have been used for emergency power for short periods of time. Diesel powered generator sets are generally installed for use when the normal service fails.

Emergency systems may provide power for such functions as: (1) Essential refrigeration; (2) Ventilation when essential to maintain life; (3) Operation of mechanical breathing apparatus; (4) Illumination and power for hospital operating rooms; (5) Fire pumps; (6) Industrial processes where current interruption would produce serious hazards; (7) Public address systems and similar functions.

DISCUSSION OF THE LESSON:

1. Discuss the emergency system needed for a hospital. How is the system approved for use? Who makes periodical tests and maintenance checks to insure proper operating conditions?

2. What current supply systems are available for installation where emergency lighting and power may be needed?

3. List some of the requirements for emergency circuits for lighting and power. Will independent wiring be required?

4. Discuss some of the controls for emergency lighting circuits. Who is responsible for overcurrent devices?

5. Explain what is meant by individual unit equipment.

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return to the class for correction and discussion.

NAME ______________________ LESSON B-25

DATE ______________________ WORKSHEET

EMERGENCY SYSTEMS

1. Who sets the requirements for an emergency system installed within a building, plant, church, hospital, or school? MUNICIPAL, STATE, FEDERAL, OR OTHER CODES, OR BY ANY GOVERNMENTAL AGENCY HAVING JURISDICTION.

2. What five types of electrical services to a building would be connected to an emergency system?

   a. LIGHTING
   b. ESSENTIAL REFRIGERATION
   c. VENTILATION (WHEN ESSENTIAL) TO MAINTAIN LIFE
   d. CRITICAL INDUSTRIAL PROCESSES
   e. FIRE PUMPS

   *ALTERNATE ANSWERS

   * OPERATION OF MECHANICAL BREATHING APPARATUS
   * POWER FOR OPERATING ROOMS
   * FIRE ALARM SYSTEMS

3. Why are emergency systems tested on a scheduled basis? TO ASSURE THEIR MAINTENANCE IN PROPER OPERATING CONDITION

4. How much capacity and rating should an emergency system have? ADEQUATE FOR THE EMERGENCY OPERATION OF ALL EQUIPMENT CONNECTED TO THE SYSTEM

5. What types of emergency systems are covered in Article 700 - Emergency Systems? Name four of them.

   a. RECHARGEABLE BATTERY UNITS
   b. STORAGE BATTERY
   c. GENERATOR SET
   d. SEPARATE SERVICES

   *ALTERNATE ANSWERS

   * CONNECTION AHEAD OF SERVICE MAIN
   * AUXILIARY SOURCE

6. What device is used to switch the emergency system on? AN AUTOMATIC TRANSFER SWITCH

7. Is "feed-thru" wiring premitted in an emergency fixture installed in a continuous row? Yes/No NO. Give the N. E. Code Section on which your answer is based. SECTION 700-17

8. Which type or types of switches are allowed on an emergency circuit to control lighting? [Check the correct answer(s).]

X a. Single-throw switches

_____ b. Switches in series

_____ c. Three-way switches

_____ d. Four-way switches

9. Would a regular automobile battery be approved for emergency system power? Yes/No NO. Give the Code paragraph which covers your answer. 700-6A NO - VOLTAGE TOO LOW - 700-6A

10. What prohibits a dry-cell battery from being approved for emergency system power? THE DRY CELL BATTERY IS NOT A RECHARGEABLE BATTERY.

MOBILE HOMES, RECREATION VEHICLES, AND PARKS

DESIRED RESULTS:

1. To acquaint the student with the N. E. Code requirements for electrical conductors and equipment installed within mobile homes, recreational vehicles, and parks.
2. To study the references related to the installation of electrical wiring, fixtures, equipment, and appurtenances in the above-named places.
3. To learn the methods of connecting the mobile home service to the power supply.

INTRODUCTION:

Have the students read what the N. E. Code says about electrical installations in the above-named areas. Review the need and the growing demands for electrical work in this area.

PRESENTING THE LESSON:

Suggested discussion questions:

1. Discuss the methods of connecting the mobile home service to the power supply.
2. What electrical installations are included in the mobile home at the factory?
3. Does each state set up its own laws concerning the wiring and inspection of mobile homes?
4. How does a prospective buyer know the type of wiring in a mobile home?
5. How is the number of branch circuits determined to a certain mobile home?
6. Define a recreational vehicle according to the N. E. Code.
7. Discuss some of the things to watch when making electrical installations in a recreational vehicle park.
8. How is this outdoor electrical equipment protected in wet locations?

APPLICATION:

Have the students complete the Assignment Sheet for this lesson.

CHECKING AND FOLLOW-UP:

Check the answers and return the sheet to the students for correction and filing in the notebooks.

NAME ______________________________ LESSON B-26

DATE ______________________________ WORKSHEET

MOBILE HOMES, RECREATIONAL VEHICLES, AND PARKS

1. Service to a mobile home is always 115/230 (120/240) volts, 1 phase, 4 wire, 60 Hertz.

2. The service conductor to a mobile home can be: (Check the correct methods.)

   X a. Thru an overhead conduit mast

   X b. One or more approved cord assemblies

   X c. An approved underground feeder

   ____ d. Open wiring on insulators

   X e. Permanent conduit connection

3. A branch circuit panelboard with its main disconnecting means must be located within the mobile home. Can this equipment be classified as service entrance equipment? Yes/No NO. Reference 550-4A

4. Does the "power take-off" outside the mobile home which feeds one of the service wiring methods in question # 2 to the mobile home have the designation of being the service equipment? Yes/No YES. Reference ______________

5. Cord assemblies used for mobile home service power supply are rated 40 or 50 amperes, 250 volts, 4 wire, at least 21 feet long but not to exceed 36 1/2 feet overall.

6. The identified conductor (white wire or neutral) and the equipment grounding conductor (green wire) are connected together at the service entrance equipment enclosure and to the grounding electrode.

   In a multi-service mobile home:

   a. Each service has a main overcurrent protective device. Yes/No YES Reference 550-4 (A)

   b. Each service neutral is isolated from the other neutrals in the other panels. Yes/No YES

   c. Each service neutral is insulated from the equipment grounding conductor. Yes/No YES

   d. Each equipment grounding bus bar for each panel is insulated from each other. Yes/No YES. Reference 550-9 (A-1)

7. What is the maximum number of power supply cords that may be used to serve a mobile home? 3

8. The minimum size feeder ampacity for a single mobile home lot is 100 amperes and is based on a load of 16,000 watts per mobile home lot. (Demand factors not included.)

9. The cord and connection assembly for a mobile home is called a POWER SUPPLY CORD and for a recreational vehicle it is called a POWER SUPPLY ASSEMBLY.

10. The minimum rated demand for a recreational vehicle is 600 watts. This would require a minimum of 1 15 ampere 120 volt circuit(s).

11. Explain how the Identified Conductor (Neutral) and the Equipment Grounding Conductor are terminated in a recreational vehicle.
THE NEUTRAL IS INSULATED FROM THE PANEL CAN. THE EQUIPMENT GROUNDING CONDUCTOR IS BONDED TO THE PANEL CAN. BOTH ARE TIED TOGETHER AT THE SERVICE EQUIPMENT REMOTE FROM THE VEHICLE.

SAMPLE HOUSE PLANS

DESIRED RESULTS:

To examine a sample house plan to determine the power load for appliances, cooling, heating, and lighting.

INTRODUCTION AND PRESENTING THE HOUSE PLANS:

The attached sample house plan should be examined, along with the help of information on the sheet, for the total power load. Also, using the three systems suggested for the heating requirements, and Notes 1, 2, 3, and 4, you should have one or two good sessions of blueprint reading.

It is suggested that the instructor make out a set of problems and questions to be used for the worksheet. Many questions may be local because of the types of equipment widely used in certain geographical or climate areas. Thus, it is suggested that these questions be prepared by the local instructor. The best way to teach Blueprint Reading is to give the student a variety of problems and questions concerning the equipment, heating area, heating load, sizes of the rooms, etc. Many problems in mathematics applied to electricity as used in a house can be prepared for this situation. Preparation and printing of the questions so that each student has a copy will be the best method of presenting the work.

APPLICATION:

Have the students examine the print using prepared questions to search out the answers.

CHECKING AND FOLLOW-UP:

Check the answers and discuss those that differ to arrive at a satisfactory understanding. File the sheet in the notebooks for keeping.

INFORMATION SHEET LESSON B-27

SAMPLE HOUSE PLAN

(BLUEPRINT READING)

The attached house plan has the following items of electrical equipment.

1.	Range - 230 V 1Ø	12 kw
2.	Disposer - 120 V	7.2 amps
3.	Dish Washer - 120 V	1350 W (13 amps)
4.	Clothes Washer - 120 V	9.8 amps
5.	Clothes Dryer - 230 V 1Ø	5.0 kw
6.	Electric Water Heater 230 V 1Ø	4.5 kw

The electric heating requirements; use one of the following systems:

ROOM NAME	SCHEME # 1 BASEBOARD	SCHEME # 2 CEILING CABLE	SCHEME # 3 CENTRAL ELECTRIC FURNACE
Living Room & Hall	3000 W	3000 W	230V 1 Ø
Dining & Kitchen	2000 W	2000 W	10 KW
Bedroom # 1	1250 W	1400 W	Duct Bank
Bedroom # 2	1250 W	1400 W	+ 1/3 HP 120V
Bedroom # 3	1000 W	1000 W	Fan
Bath # 1	500 W	400 W	
Bath # 2 (Half Bath)	500 W	200 W	

NOTES:

1. Optional cooling is by either of the following systems:

	Baseboard or Ceiling	Electric Furnace
Bedroom # 1	6.9 amp @ 230 V window unit	20,000 BTU Condenser @14.6 amps
Dining & Kitchen	9.8 amp @ 230 V window unit	230V + Fan at Furnace

NOTES (Continued):

2. It is interesting to note that the heating loads are different for the various systems. This is due to standard sizes of items and not from one system being more efficient or less expensive to operate than another.

   Baseboard Heaters - 8500 watts

   Ceiling Cables - 9400 watts

   Electric Furnace - 10000 watts

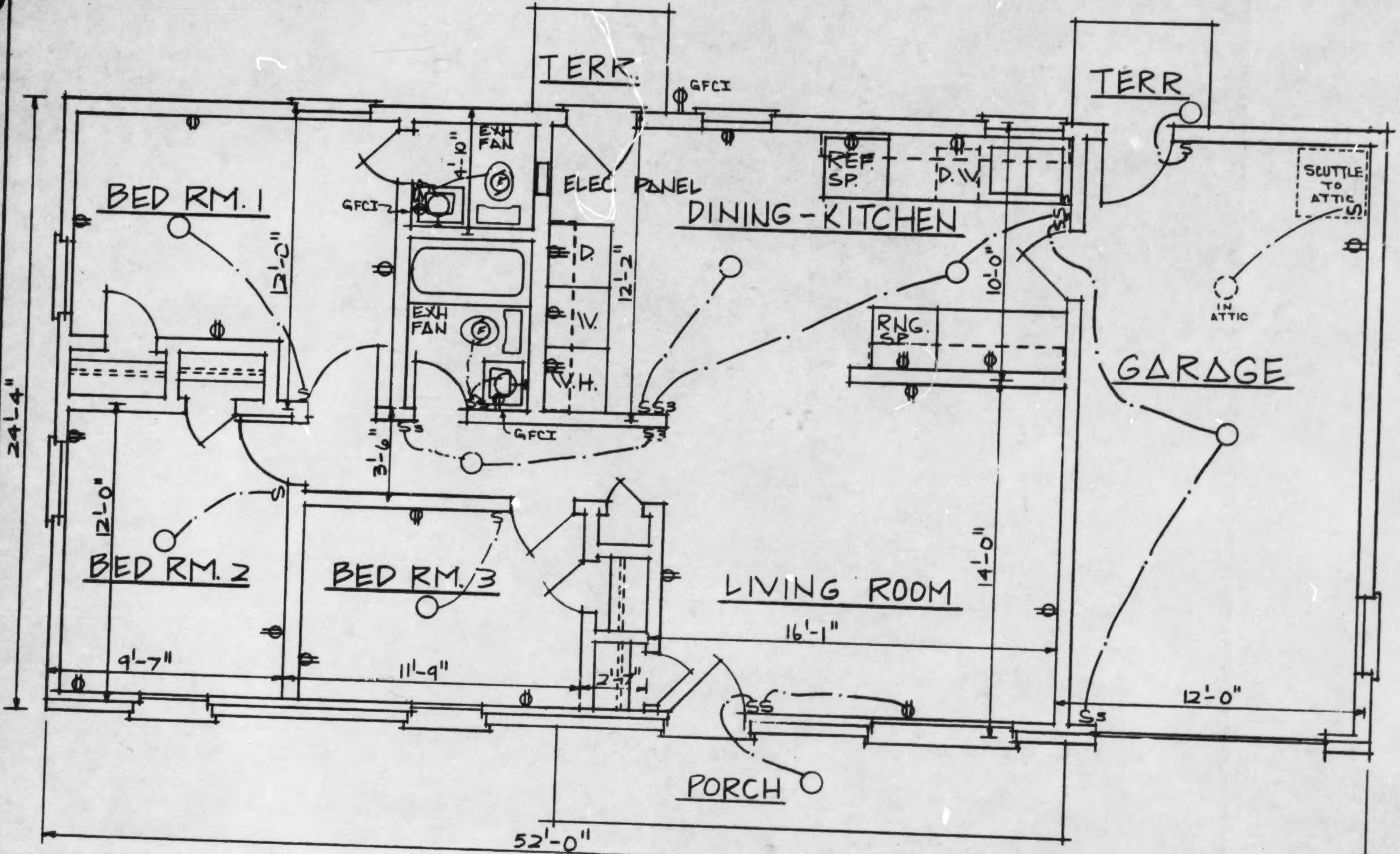
3. By the same reasons, the cooling systems differ:

   Central unit in furnace - 20,000 BTU

   Dining/Kitchen window unit - 15,000 BTU

   Bedroom # 1 window unit - 8,000 BTU

4. Both heating and cooling requirements assume construction typical for a home which qualifies for the "all-electric" rate from the serving utility, and a design temperature range for heating of 10° F outside and 70° F inside. Naturally, it would not be as much of a temperature differential for the cooling - 70° F inside to 95° F outside (estimated averages).


TERR.
GFCI
TERR
BED RM. 1
EXH FAN
1'-10"
GFCI
ELEC. PANEL
DINING-KITCHEN
REF. SP.
D.W.
SCUTTLE TO ATTIC
13'-0"
D.
12'-2"
IV.
V.H.
EXH FAN
RNG. SP.
10'-0"
IN ATTIC
GARAGE
24'-4"
12'-0"
3'-6"
GFCI
BED RM. 2
BED RM. 3
LIVING ROOM
16'-1"
14'-0"
9'-7"
11'-9"
2'-7"
12'-0"
PORCH
52'-0"

1978

FLOOR PLAN

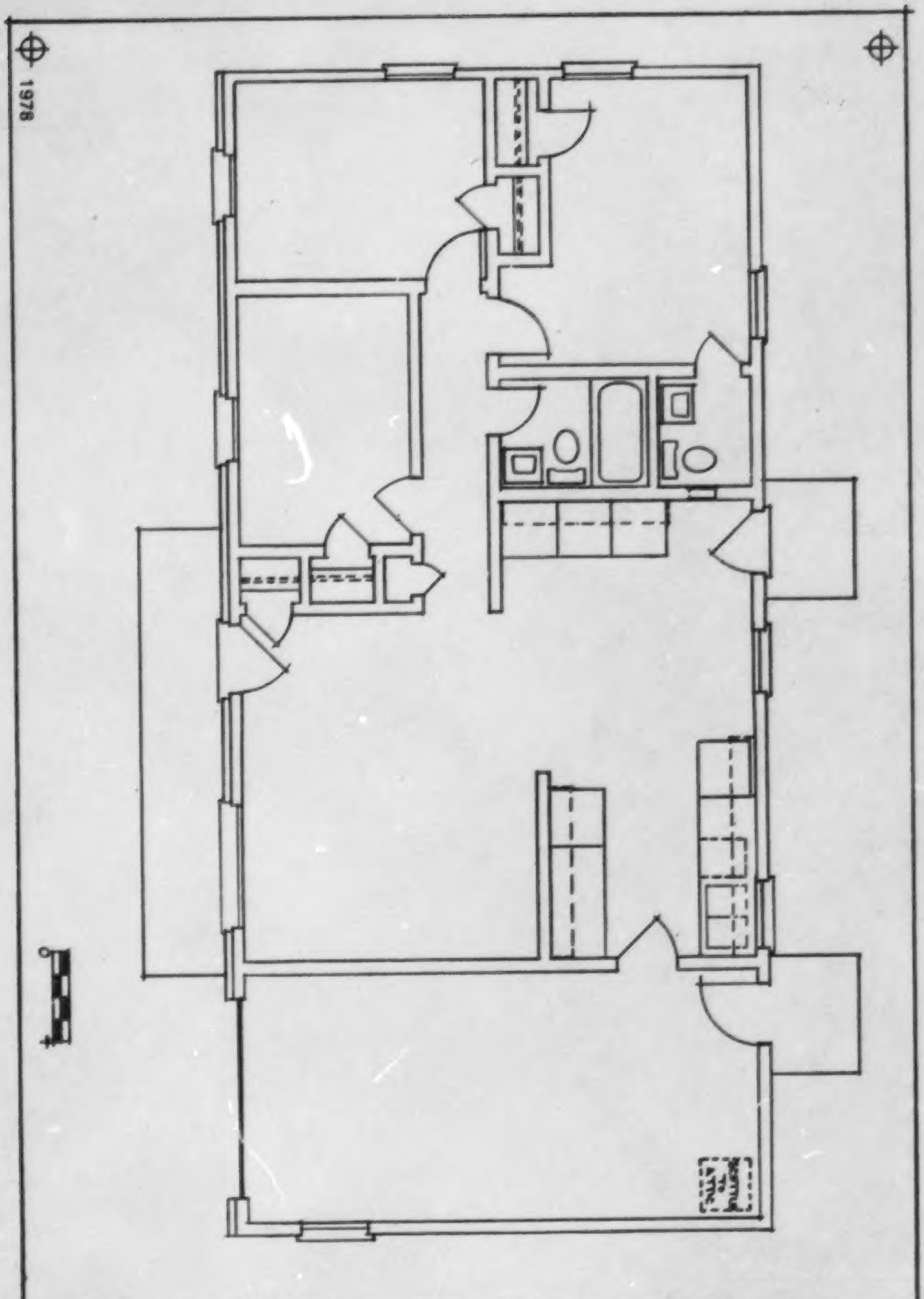
0 4

STUDENT: GARY ROBBINS
STUDENT NO. 6248
326 PINEVIEW ST
ASHEBORO, N.C.
SHEET NO. 1 OF 1

FLOOR PLAN

GUILFORD TECHNICAL
INSTITUTE, JAMESTOWN N.C.

ARCHITECTURAL
TECHNOLOGY DEPARTMENT



GUILFORD TECHNICAL
INSTITUTE, JAMESTOWN, N.C.

ARCHITECTURAL
TECHNOLOGY DEPARTMENT

FLOOR PLAN

STUDENT: GARY ROBBINS
STUDENT NO. 6248
326 PINEVIEW ST.
ASHEBORO, N.C.

SHEET NO. 1 OF 1

TERR.

TERR.

EXH.
FAN.

REF.
SP.

D.
W

ELEC. PANEL

DINING-KITCHEN

BED RM. 1

D.

EXH.
FAN.

W

RNG.
SP.

GARAGE

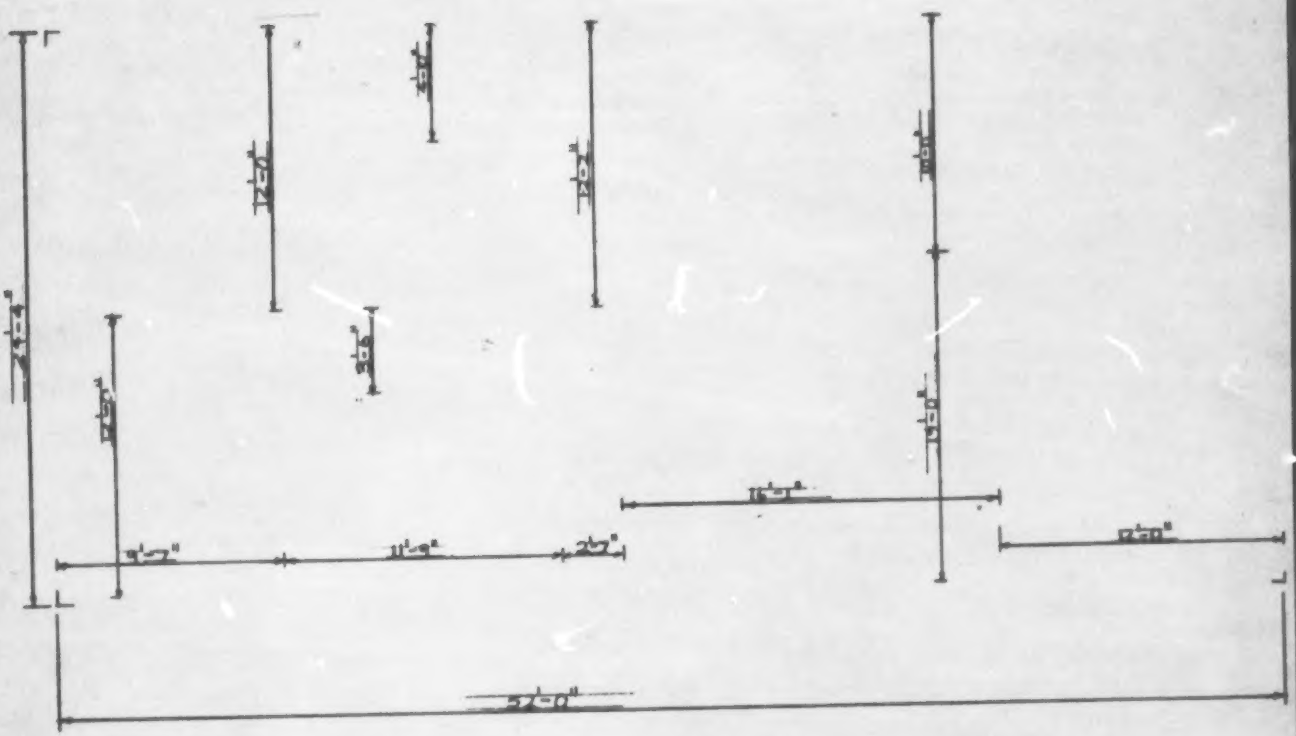
W.H.

BED RM. 2

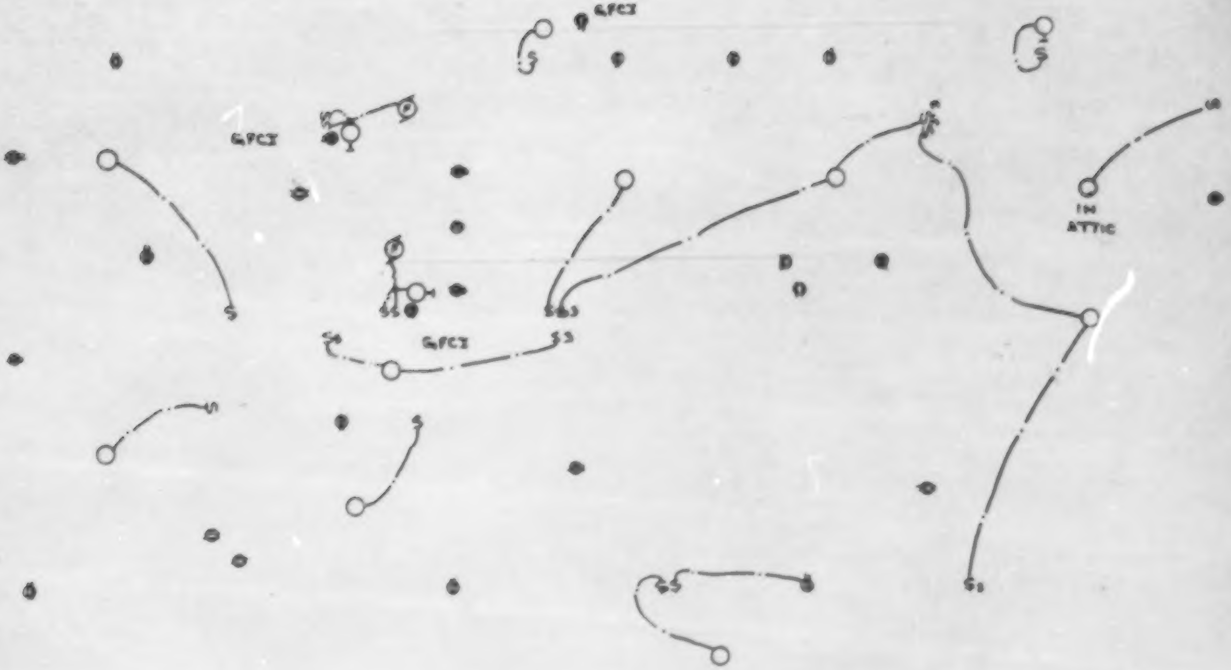
BED RM. 3

LIVING ROOM

PORCH


9'-7"
11'-9"
2'-7"
16'-1"
12'-0"
52'-0"

1978


GFCI
GFCI
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S3
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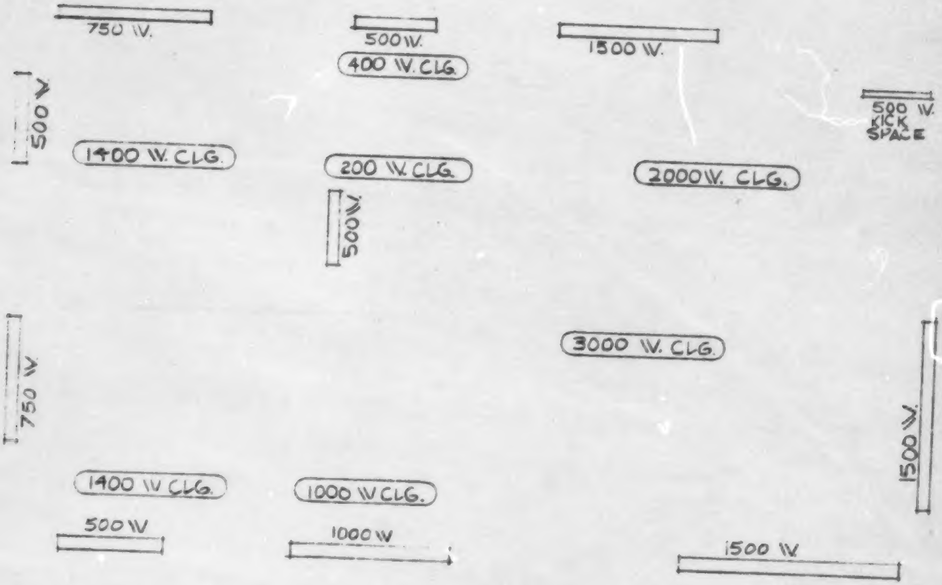
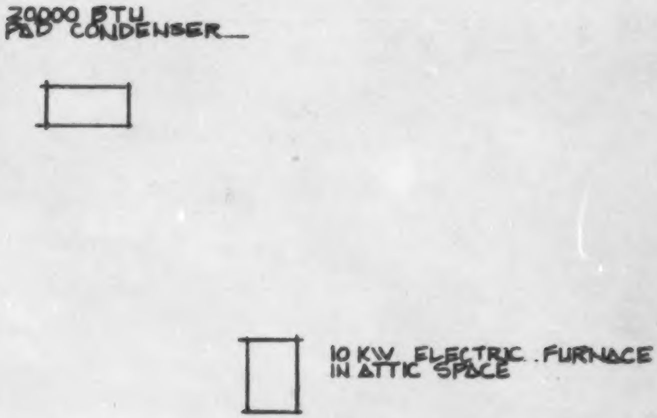
S3

1978


750 W.
500 W.
400 W. CLG.
1500 W.
500 W.
500 W. KICK SPACE
1400 W. CLG.
200 W. CLG.
2000 W. CLG.
500 W.
3000 W. CLG.
750 W.
1500 W.
1400 W CLG.
1000 W CLG.
500 W
1000 W
1500 W

8500 KW BASE BOARD HEAT
OR
(9400 KW CEILING CABLE HEAT)

1978


20000 BTU
PAD CONDENSER
10 KW ELECTRIC FURNACE
IN ATTIC SPACE

10 KW ELECTRIC FURNACE
WITH AIR CONDITIONER

1978

8000 BTU
AIR CONDITIONER
15000 BTU
AIR CONDITIONER

WINDOW AIR CONDITIONERS
2300 BTU

1978

OUTLET CIRCUITING

INTRODUCTION:

Calculation of building loads is based on Chapter 2 of the N. E. Code. The several optional methods of calculating a residential service make the task of providing correct answers an almost impossible task. Answers to the more standard circuits have been provided. The material outlined should be broken down into three or more class sessions.

PRESENTING THE LESSON:

The instructor should make the student aware of the various optional methods of calculating services and feeders and provide him with assistance and guidance in completing his assignment with the one method chosen/assigned. A class discussion of these different means of determining service sizes should provide a healthy group discussion. Not only should the electrical aspects of the problem be discussed, but the economic value of more circuits with less loading, customer satisfaction, and safety of individualized circuits for major items which require power should be weighed.

APPLICATION:

When the student has correctly figured the General Lighting loads and appliance outlets, and has understood the various methods of arriving at the correct answers, have him move on to the larger appliance circuits and one of the schemes for heating and air conditioning. The student should group certain loads where permissible, size the feeder required, and determine the correct overcurrent protective device needed for the feeder.

CHECKING AND FOLLOW-UP:

When all circuits have been developed, loads totaled, and feeders sized, have the student lay out the necessary circuits in the panel. Now, have the student size the service feeders, the grounding conductor, and the bonding required to completely and correctly meet the Code installation requirements.

NAME ______________________________ LESSON B-28

DATE ______________________________ WORKSHEET

OUTLET CIRCUITING

1. From the floor plan in Assignment B-27, calculate the load data and circuit the following on your floor plan:

   (a) Lighting outlets. Load in watts ____________

   (b) Receptacle outlets. Load in watts ____________

   (c) Small appliance outlets. Load in watts ____________

2. List the number and ampacity of the circuits required for:

   (a) Lighting outlets:
   Number required ____________________.
   Ampacity of circuits ______________.

   (b) Receptacle outlets:
   Number required ____________________.
   Ampacity of circuits ______________.

   (c) Small appliance outlets:
   Number required ____________________.
   Ampacity of circuits ______________.

3. From the information sheet in assignment B-27, complete the following schedule:

ITEM	VOLTAGE	AMPS	WATTS	WIRE SIZE	CIRCUIT PROTECTION
Range	230	34.7	12000*	# 8	50
Disposer	120	7.2	864	#14	15
Dishwasher	120	13.0	1350	#14	15
Clothes Washer	120	9.8	1176	#12	20
Clothes Dryer	230	21.7	5000	#10	30
Water Heater	230	19.5	4500	#10	30

* Use Demand Table 220-5

4. From the Information Sheet in Assignment B-27, select one of the three schemes of heating. Give your answer to the following:

   (a) Scheme chosen ________________________________

   (b) Number of circuits required _________________

   (c) Ampere rating of each circuit ________________

   (d) Overcurrent protective devices needed for these circuits and their ampere rating _________________________

5. From the Information Sheet in Assignment B-27, select one of the two methods of cooling which would match the heating system you chose above. Give your answer to the following:

   (a) Scheme chosen ________________________________

   (b) Number of circuits required _________________

   (c) Ampere rating of each circuit ________________

   (d) Overcurrent protective devices needed for these circuits and their ampere rating _________________________

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APPENDIX

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-1 THRU B-5
TEST B-1

1. Which phase (or leg) would be labeled as the "High Leg"? PHASE B What is its N. E. Code color coding? ORANGE List the N. E. C. Reference. 215-8

2. What color coding is applied to the "Intentionally grounded" conductor of the transformer? WHITE What is the common term for this conductor? NEUTRAL

3. List two ways to obtain 120 volt power in an installation using a three phase, "3 wire delta" service. (a) TRANSFORMERS or (b) SEPARATE SERVICE

4. List four reasons for providing separate circuits for lighting loads and motor loads.

   (a) LARGE STARTING CURRENT OF MOTOR MAY CAUSE LIGHTS TO GROW DIM OR BLINK.

   (b) OVERLOADS AND SHORT CIRCUITS ARE MORE COMMON IN MOTOR CIRCUITS AND WOULD CAUSE LIGHTS TO GO OUT.

   (c) LIGHTING REQUIRES CLOSER VOLTAGE REGULATION THAN MOTOR CIRCUITS.

   (d) IT IS GENERALLY MORE ECONOMICAL TO OPERATE MOTORS AT A HIGHER VOLTAGE THAN THAT OF A LIGHTING CIRCUIT.

5. MATCH: Place the number representing the name of the Instrument in Column B on the line giving the use, Column A.

	Column A	Column B
3	a. An instrument used to measure VOLTAGE.	1. Ohmmeter
5	b. An instrument used to measure POWER.	2. Ammeter
2	c. An instrument used to measure CURRENT.	3. Voltmeter
1	d. An instrument used to measure RESISTANCE.	4. Megameter
		5. Wattmeter

6. When using a Voltmeter to test a circuit, how should it be connected? PARALLEL OR SHUNT

NAME ______________________________ TEST B-1

7. Give one main purpose of a "megger" or megameter.

CHECK CONDUCTOR INSULATION RESISTANCE. (HIGH RESISTANCE)

PAGE 1-64 SEC. 181

8. What is a multi-meter? AN INSTRUMENT USED TO CHECK VOLTAGE, CURRENT, AND OHMS USING ONE METER MOVEMENT, AND SELECTOR SWITCH.

9. Explain the "Bell" or "Buzzer" method for location and identifying conductors. PAGE 1-73 SEC. 201

10. What are the two windings of a transformer called?

(a) PRIMARY (b) SECONDARY

11. List three types of losses in a transformer:

(a) EDDY CURRENT (b) *COPPER (c) *IRON

*THESE LOSSES EXPRESSED IN WATTS ARE HEAT LOSSES AND PERFORM NO USEFUL WORK.

12. Basic construction of a transformer consist of the following:

(a) PRIMARY WINDINGS (b) SECONDARY WINDINGS

(c) CORE

13. List six main classifications of transformers:

(a) AUTOTRANSFORMER

(b) CONSTANT POTENTIAL

(c) NETWORK

(d) INSTRUMENT

(e) CURRENT

(f) CONTROL

14. The input of a transformer is the same as the output plus copper and iron losses. True/False TRUE

15. Find the percent regulation of a transformer which reads 575 volts secondary at no load and 550 volts secondary at full load.

$$\text{Percent Reg.} = \frac{\text{No load sec.} - \text{full load sec.}}{\text{Full load sec.}}$$

$$\% = \frac{575 - 550}{550} = \frac{25}{550} = 4.5\%$$

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-1 THRU B-5
TEST B-1

16. Match the capital letter on each of the following schematic drawings to the proper transformer description:

__D__ Transformer having single primary winding and dual secondary windings, with secondary connected in series.

__A__ Transformer having dual primary connected in series and dual secondary connected in parallel.

__F__ Transformer having dual primary connected in series and dual secondary connected in series.

__E__ Transformer having single primary and secondary windings.

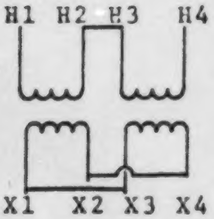
__B__ Transformer connected additive polarity.

__G__ Transformer connected subtractive polarity.

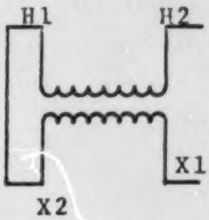
__C__ Autotransformer.

__H__ Transformer having dual primary connected in parallel and single secondary windings.

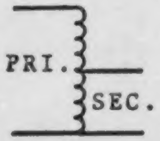
A.


H1
H2
H3
H4
X1
X2
X3
X4

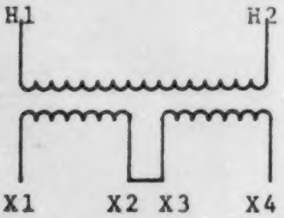
B.



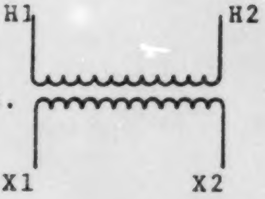
C.



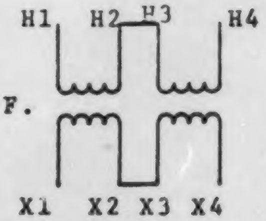
D.


H1
H2
X1
X2
X3
X4

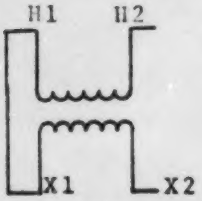
E.



F.


H1
H2
H3
H4
X1
X2
X3
X4

G.



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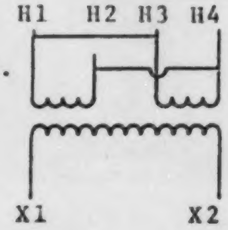

H1
H2
H3
H4
X1
X2

NAME ______________________ **TEST B-1**

17. The autotransformer is the most efficient and effective means of increasing or decreasing voltage. True/False TRUE

18. Coils of either a single phase or a three phase transformer may be connected for operating as an autotransformer. True/False TRUE

19. What three factors make the installation of a three-phase transformer more advantageous than a bank of single phase transformers operating as a unit?

(a) LOWER COST

(b) HIGHER EFFICIENCY

(c) LESS SPACE REQUIRED TO INSTALL

* ALTERNATE ANSWER

* LOADS CAN BE BALANCED BETTER

20. What two basic installation precautions should be followed in mounting any transformer?

(a) PROPER LOCATION

(b) PROPER MOUNTING

21. List two reasons for connecting the primary and secondary neutrals in wye-wye connected transformers:

(a) LINE TO NEUTRAL VOLTAGES WOULD BE VERY UNSTABLE

(b) INSULATION STRESSES WOULD RESULT BECAUSE OF UNSTABLE VOLTAGE

22. A three phase transformer is three SINGLE phase transformers connected in SERIES and enclosed in a single housing.

23. A step-up transformer INCREASES the voltage and DECREASES the current.

24. List two disadvantages of the open delta transformer connection:

(a) LARGE UNBALANCE IN SECONDARY VOLTAGE

(b) LARGE UNBALANCE IN PRIMARY CURRENT

25. Taps on a transformer are used for CHANGING the voltage by a small amount - usually 2 1/2 % per step.

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-6 THRU B-10
TEST B-2

1. What are the eight main types of fixed electric space heating equipment?

(a) ELECTRIC FURNACES
(b) HYDRONIC ELECTRIC BOILER
(c) HEAT PUMP
(d) BASEBOARD HEATERS
(e) ELECTRIC FIREPLACES
(f) FLOOR CABLES
(g) DUCT HEATERS
(h) INFRARED HEATERS

*ALTERNATE ANSWERS
*WALL MOUNTED HEATERS - RADIANT, FORCED AIR
*CEILING MOUNTED HEATERS - HEAT VENT LIGHT COMBINATIONS, RESISTANCE HEATERS, RADIANT LAMPS, RADIANT PANELS, CEILING CABLES
*UNIT HEATERS

2. The size of branch-circuit conductors supplying fixed electric space heating equipment shall be sized on the basis of 125 % of the total connected load.

3. The overcurrent protective device for the above branch circuit conductor must be sized for 125 % of the total connected load.

4. The maximum overcurrent protection for resistance-type space heating equipment is 60 amperes. The maximum load shall not exceed 48 amperes.

5. The fan and duct heater circuits must be INTERLOCKED so the movement of air across the heater is assured.

6. The load for de-icing and snow-melting equipment is considered as CONTINUOUS. This means the overcurrent protective device and the branch circuit conductor must be sized for 125 % of the load.

7. Can the non-heating leads of de-icing and snow-melting equipment be shortened? Yes/No YES Give the N. E. Code Section for your answer. 426-11 Is this different from indoor ceiling and floor cable installations? Yes/No YES Give the N. E. Code Section for your answer. 424-22 (c)

8. The nominal covering for embedded cables is 1 1/2 inches below the surface.

NAME ______________________ TEST B-2

9. The Code requires cables to be tested before COVERING. The careful electrician will test the cable before installation, before COVERING, and AFTER covering.

10. The Code requires that conductors and equipment be approved. What is meant by approved? 110-2 AND DEFINITION 100
ONLY WHEN ACCEPTABLE TO THE AUTHORITY ENFORCING THIS CODE.

11. Match Column A with Code Numbers in Column B.

	Column A	Column B
4	(a) Manditory Rules	(1) 110-6
3	(b) Circuit Voltage	(2) 110-8
1	(c) Conductor Gages	(3) 110-5
2	(d) Wiring Methods	(4) 110-3
		(5) 110-9

12. Give Code Section that tells how all equipment shall be installed.
110-12 How shall it be installed? INSTALLED IN A NEAT AND WORKMANLIKE MANNER.

13. True or False - Mark T or F on line after statement and give Code references.

(a) All electrical equipment shall be identified by the manufacturer's name or trademark. TRUE Reference 110-21

(b) When the wiring system is completed, all wiring shall be free from short circuits and grounds. TRUE Reference 110-7

(c) The Code permits you to put a shelf (for storage purposes) across the front of a panel if it is a removable type. FALSE
Reference 110-16 (B)

(d) All conductors shall be spliced or joined with approved splicing devices. TRUE Reference 110-14 (B)

(e) The Code permits the use of wooden pegs driven into holes in masonry walls to fasten electrical equipment to the wall. FALSE
Reference 110-13 (A)

(f) If equipment operates at more than 50 volts, and not more than 600 volts is elevated at least 8 feet above the floor it does not need to have a guard over "live parts." TRUE Reference 110-17 (A-4)

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-6 THRU B-10
TEST B-2

14. All interior wiring systems shall have a grounded conductor. How is this conductor identified? WHITE OR NATURAL GRAY COLOR

15. In cable wiring, what section of the N. E. Code allows the identified conductor (white wire) to be used as the "return conductor" from the switch to the outlet? ARTICLE 200-7 EXCEPTION 2

16. Grounded conductor shall be connected to SCREW - SHELL terminal.

17. Identified conductor shall be connected to identified WHITE colored terminal to screw-shell.

18. Grounded terminal shall be identified by WHITE METALLIC coating.

19. The equipment grounding conductor terminal on the receptacle shall be GREEN color.

20. The grounded circuit conductor terminal on the receptacle shall be WHITE color.

21. List two types of grounds used in an interior wiring system.

(a) SYSTEM GROUND (NEUTRAL)

(b) EQUIPMENT GROUND

22. The minimum copper grounding conductor for an A.C. system shall be No. 8 AWG.

23. The maximum copper grounding conductor required for an A. C. system is No. # 3/0 AWG.

24. The resistance of made electrodes shall not exceed 25 ohms.

25. The minimum length of buried metallic water piping system permitted as a grounding electrode shall be 10 feet.

26. In general, underground water pipes have a resistance to ground of less than 3 ohms.

27. All portable tools shall be GROUNDED.

28. Service entrance conduit shall be GROUNDED.

NAME ____________________ TEST B-2

29. Metal frame constructed building shall be GROUNDED.

30. List at least five approved types of grounding electrodes.

(a) METALLIC WATER PIPE

(b) CONCRETE-ENCASED ELECTRODE

(c) PLATE ELECTRODE

(d) PIPE OR CONDUIT ELECTRODES

(e) ROD ELECTRODES

NAME ____________________

DATE ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-11 Thru B-16
TEST B-3

1. Where conductors of different systems are installed in the same gutter or raceway, handling more than one identified conductor, how shall they be marked? FIRST NEUTRAL CONDUCTOR WHITE OR GREY; OTHER NEUTRAL WHITE WITH COLORED STRIPE.

   Reference ART. 210-5 (A)

2. (a) What section of the Code covers ground-fault circuit protection on 15 and 20 ampere receptacle outlets on single phase circuit at construction sites? 210-8 (B)

3. Give minimum size copper conductor for the following branch circuit classification (75°C).

   (a) 15 ampere branch circuit #14 AWG

   (b) 20 ampere branch circuit #12 AWG

   (c) 30 ampere branch circuit #10 AWG

   (d) 65 ampere branch circuit # 6 AWG

4. The Code requires additional receptacles above the 200 watts per ft.

   (a) Give Section 210-25 (D)

   (b) Where are they located? ONE RECEPTACLE FOR EACH 12 LINEAR FT. ABOVE THE SHOW WINDOW.

5. What is a multiwire branch circuit? ARTICLE 100 DEFINITION

   Reference Code ART.210-4

NAME ______________________________ TEST B-3

6. What is meant by:

(a) Fixed appliance? IS FASTENED OR SECURED TO ONE LOCATION

(b) Portable appliance? ONE THAT IS ACTUALLY MOVED OR CAN EASILY BE MOVED FROM ONE LOCATION TO ANOTHER.

(c) Stationary appliance? CANNOT BE EASILY MOVED FROM ONE LOCATION TO ANOTHER IN NORMAL USE.

7. What are the Branch Circuit requirements for small appliances in a residence? TWO OR MORE 20 AMPERE BRANCH CIRCUITS

8. Does the Code require you to put a laundry circuit in all dwellings? NO Give Code Section to back up answer. 210-25 (B)

9. Is it permissible to load a circuit to its capacity with portable or stationary appliances? NO (80%) 210-23 (A)

10. When there is a protective device rating marked on appliance, is it permissible to use a larger branch circuit overcurrent device?
NO 422-6

11. Name the five basic items that should be included in a feeder diagram. (215-5)

(a) AREA IN SQUARE FEET
(b) LOAD (BEFORE APPLYING DEMAND FACTORS)
(c) DEMAND FACTORS SELECTED
(d) COMPUTED LOAD (AFTER APPLYING DEMAND FACTORS)
(e) SIZE OF CONDUCTORS

12. Give Unit Load per square ft. for General Lighting Load that applies to the following:

	Answer	References
(a) Banks	5	220-2 (B)
(b) Court Rooms	2	" "
(c) Office Building	5	" "
(d) Dwellings (other than Hotels)	3	" "
(e) Schools	3	" "
(f) Restaurants	2	" "

NAME ______________________

DATE ______________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-11 THRU B-16
TEST B-3

13. How many circuits would be required for General Lighting in a dwelling having 2100 square ft.? 5 CIRCUITS. Give Code Section reference. 220-3 (A)

14. When calculating load for a dwelling, is the demand factor applied to the 2 kitchen and laundry circuits? KITCHEN CIRCUIT - YES
LAUNDRY CIRCUIT - YES
Reference 220-16 (A&B)

15. When computing the square footage of a building for a general lighting load, what dimensions are used? OUTSIDE Code Section Ref. 220-2 (B)

16. What does the service consist of? SERVICE CONDUCTORS AND SERVICE EQUIPMENT Reference PAGE 9-177

17. (a) What is meant by service drop conductors? THE OVERHEAD SERVICE CONDUCTORS FROM THE LAST POLE OR OTHER AERIAL SUPPORT TO AND INCLUDING THE SPLICES, IF ANY, CONNECTING TO THE SERVICE ENTRANCE CONDUCTORS AT THE BUILDING OR OTHER STRUCTURE.

(b) What is meant by service-entrance conductors? (OVERHEAD) THE SERVICE CONDUCTORS BETWEEN THE TERMINALS OF THE SERVICE EQUIPMENT AND A POINT USUALLY OUTSIDE THE BUILDING, CLEAR OF BUILDING WALLS, WHERE JOINED BY TAP OR SPLICE TO THE SERVICE DROP.

18. Must there be means to disconnect the grounded conductor from the interior wiring, at the service disconnect switch? YES Give Code Section Reference. 230-75

19. Service equipment enclosures SHALL be grounded. (Should or Shall) Give Code Section. 230-63

20. Define a Master Service. A SERVICE THAT SUPPLIES MORE THAN ONE BUILDING UNDER A SINGLE MANAGEMENT.
Give your reference. ELECTRICIAN HANDBOOK PAGE 9-162

21. Article 305 of the N. E. Code sets the requirements for temporary wiring. True/False FALSE Reference or Reason 305-1

22. Temporary wiring can only be used for 90 days for any type temporary installation. True/False FALSE
Reference or Reason 305-1 (B)

NAME ______________________________ TEST B-3

23. Ground-fault circuit protection is required for all 15 and 20 ampere receptacle outlets. True/False. FALSE
Reference or Reason 210-8

24. Can a two-wire 120 volt 15 ampere receptacle be used as an outlet for a 1/4 H. P. drill motor on a construction site? Yes/No NO
Reference or Reason 210-(c)

25. Does every branch circuit which supplies receptacles or fixed equipment have to contain a separate equipment grounding conductor?
Yes/No. NO 305-2 (D)

26. A 3/4 inch diameter by 10 foot copper-clad ground rod is approved as an earth return for a receptacle which has no equipment grounding conductor in the circuit feeding the receptacle. True/False FALSE
Reference or Reason 305-2 (E)

27. Give the minimum size conductors for the following:

(a) Overhead spans #10 AWG UP TO 50 FT. SPANS #8 AWG FOR SPANS GREATER THAN 50 FEET. 225-6 (A)

(b) Festoon lighting #2 AWG UNLESS SUPPORTED BY MESSENGER WIRE. 225-6 (B)

(c) Over 600 volts #6 WHEN OPEN INDIVIDUAL CONDUCTORS AND #8 WHEN IN A CABLE ASSEMBLE. 225-6 (A)

28. What is minimum separation of conductors exposed to weather? Also support bracket separation? 225-14 (A) & 230-51 (C)

1. SIX INCHES AND BRACKET SEPARATION OF 9 FT.
2 TWELVE INCHES AND BRACKET SEPARATION OF 15 FT.
3. OR THREE INCHES AND BRACKETS SEPARATION OF 4 1/2 FT. IF VOLTAGE IS 300 VOLTS OR LESS

29. What are the minimum clearances in feet of open conductors not over 600 volts?

(a) Above finish grade	10 FT. (225-18)
(b) Residential driveways	12 FT.
(c) Parking lots not subject to truck traffic	15 FT.
(d) Public streets	18 FT.
(e) Over roof	8 FT. (225-19)

NAME ____________________

DATE ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-17 THRU B-19
TEST B-4

1. What are the three principal types of D. C. motors?
   - (a) SHUNT-WOUND
   - (b) SERIES-WOUND
   - (c) COMPOUND-WOUND

2. The speed of D. C. motors can be controlled by what two general classifications?
   - (a) ARMATURE CONTROL
   - (b) FIELD CONTROL

3. The actual effective voltage in an armature of a D. C. motor is the APPLIED voltage less the COUNTER-EMF.

4. Shunt motors are considered as CONSTANT speed motors.

5. Series motors are considered as VARIABLE speed motors.

6. To generate electricity, there must be a relative motion between a CONDUCTOR and a MAGNETIC field.

7. In D. C. generators, the armature is always the ROTOR. In most A. C. generators, the armature is STATIONARY.

8. In a 3 Ø "wye" or "star" alternator, the line voltage across any two line levels is the VECTOR SUM of the individual phase voltages. The line voltage is 1.73 times the phase voltage. Line and phase currents are EQUAL.

9. In a 3 Ø "delta" alternator, the line voltages are EQUAL to the phase voltage, but the line currents will be equal to the VECTOR SUM of the phase currents. The line current will be 1.73 times the phase current.

10. The starting WINDING has a HIGHER resistance than the running winding of a split-phase motor, thus the interaction of the rotating magnetic field provides a starting TORQUE for the motor.

11. The angular phase displacement in a split-phase motor is approximately 45 to 30 degrees in time.

12. Overheating of the winding insulation may be caused by LOW VOLTAGE, DAMP WINDINGS, and TOO HEAVY currents.

NAME ______________________________ **TEST B-4**

13. Two-speed split-phase motors have TWO sets of windings, ONE SET for each speed.

14. Permanent SPLIT CAPACITOR motors are used for fans and blowers.

15. In a repulsion motor, the STATOR poles are repelled by the ROTOR poles causing the ROTOR to rotate.

16. The SERIES (UNIVERSAL) motor operates on A. C. or D. C. circuits.

17. The ARMATURE is connected in series with the FIELD in a universal motor.

18. List two types of universal motors:
    (a) COMPENSATED
    (b) NON-COMPENSATED

19. The COMPENSATED universal motor has an extra winding embedded in the poles of the starter.

20. The COMPENSATED universal motor is a low-horsepower motor operating at MODERATE speeds.

21. List the three major types of three-phase motors:
    (a) STRAIGHT INDUCTION
    (b) WOUND ROTOR-VARIABLE SPEED
    (c) SYNCHRONOUS (HAVING SEPARATELY EXCITED FIELD)

22. In a three-phase motor, the windings are 120 electrical degrees apart.

23. List two methods of connecting a three-phase motor stator to a three phase power source.
    (a) DELTA Δ
    (b) WYE Y

24. The SQUIRREL - CAGE motor operates on the induction principle.

25. List the four conditions which regulate the speed of a squirrel-cage motor:
    (a) AIR GAP
    (b) FREQUENCY
    (c) NUMBER OF POLES IN WINDING
    (d) LOAD ON MOTOR

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-17 THRU B-19
TEST B-4

26. The squirrel-cage motor is considered to be a STRAIGHT - INDUCTION type.

27. In a wound-rotor motor, the starting SPEED and current, FULL load and TORQUE of the motor can be controlled.

28. The wound-rotor motor is used for equipment having constant TORQUE LOADS and INCREASING HORSEPOWER up to full-rated load.

29. The two windings of three-phase induction motors are located in the STATOR and ROTOR.

30. List two important characteristics of a synchronous motor:

(a) POWER FACTOR CORRECTION

(b) CONSTANT SPEED

31. What type motor is used to transmit information in the form of electrical signals? SYNCHRONOUS MOTOR

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-20 THRU B-22
TEST B-5

1. Explain what the N. E. Code means when it specified that some equipment shall be "in sight from" another equipment.

EQUIPMENT MUST BE VISIBLE AND NOT MORE THAN 50 FEET DISTANCE.

430-4

2. List the information that should be on the name plate of a motor:

(a) MAKER'S NAME

(b) RATE VOLTS AND FULL LOAD AMPERES

(c) RATED FREQUENCY, NUMBER OF PHASES, IF AC OR DC CURRENT

(d) RATED SPEED

(e) RATED TEMPERATURE

(f) TIME RATING

(g) RATED HORSEPOWER

(h) CODE LETTER

(i) SECONDARY VOLTAGE IF A WOUND-ROTOR INDUCTION MOTOR

(j) WINDING

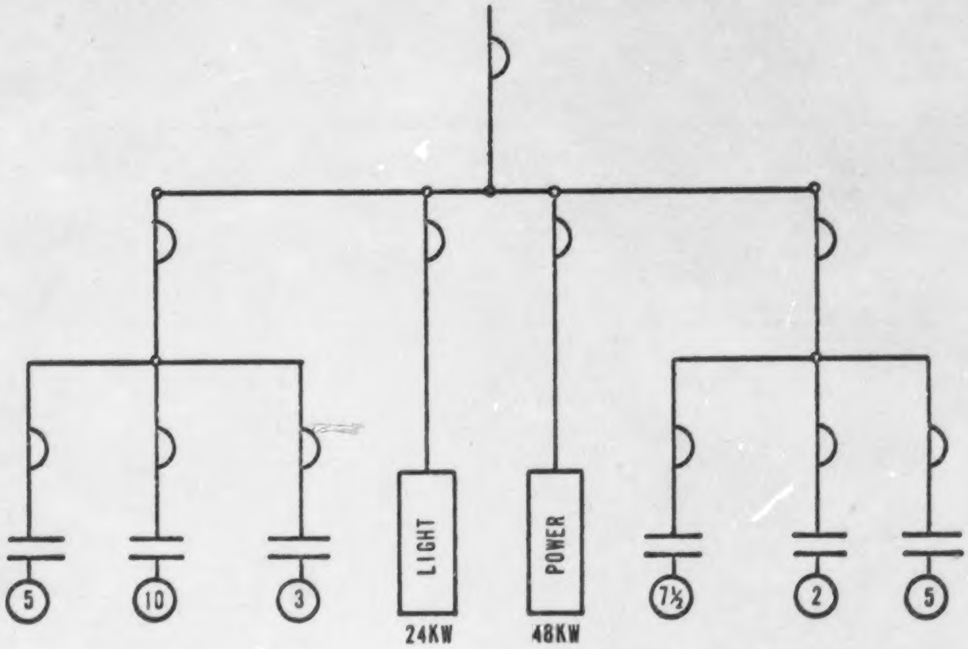
3. What are the three types of motor circuit conductors? Give the N. E. Code Section for each type.

	Types	Code Section
(a)	CIRCUITS SUPPLYING SINGLE MOTORS	430-22
(b)	CONDUCTORS SUPPLYING SEVERAL MOTORS	430-24
(c)	CONDUCTORS SUPPLYING A COMBINATION LOAD	430-25

NAME ________________________________ TEST B-5

4. **PROBLEM:** Using the National Electrical Code as reference, find the following for the electrical system below rated 120/208 volts, three phase, four wire:

a. Minimum feeder size
b. Maximum feeder overcurrent protection
c. Minimum branch circuit conductors
d. Maximum branch circuit overcurrent protection
e. Maximum motor-running overcurrent protection



NOTE: All motors 3 Ø with 40° C. rise.
Use code letter "F" for 5 HP motors.
Use code letter "A" on the other motors.
Use 75° centigrade wire temperature (copper).

ANSWER SHEET (4) TEST B-5

1. a. Motor # 1 5 HP
    1. Running current 430-150 15.2 + 10% = 16.7 or 17
    2. Running overcurrent 430-32 125% of running current. 16.7 + 4.1 = 20.8 or 21 amps
    3. Branch circuit - 430-22 17 + 25% = 17 + 4 = 21 amps 12% - #10 AWG
    4. Fuses 430-152 300% = 17 x 3 = 51 = 50 amp 240-4 (b)
    5. Disconnect - 60 amp

    b. Motor # 2 10 HP
    1. Running current 430-150 28 + 10% = 30.8 or 31 amps
    2. Running overcurrent 430-32. 30.8 + 25% = 30.8 + 7.7 = 38.5 amps #8 AWG
    3. Branch circuit - 430-22 31 + 25% = 31 + 7.75 = 39 amps
    4. Fuses - 430-152 150% 1.5 x 31 = 46.5 240-4 (b) 50 Amp fuses
    5. Disconnect 100 Amp

    c. Motor # 3
    1. Running current 430-150 9.6 + 10% = 10.5 or 11 Amps
    2. Running overcurrent 430-32 11 + 25% = 11 + 2.7 = 13.7 Amps
    3. Branch circuit 430-22 11 + 25% = 11 + 2.75 = 14 Amps # 14 AWG
    4. Fuses - 430-152 - 150 11 x 1.5 = 16.5 Amps 20 fuses
    5. Disconnect 30 Amp. Under normal conditions 30 Amp and disconnect would be sufficient.

2. Lights
    1. Branch circuit 2400 ÷ 360 = 66.6 or 67 Amps # 4 AWG (4 Cord)
    2. Fuses 240-4 (b) 70 Amp
    3. Disconnect 100 Amp

3. Power
    1. Branch circuit 48 kW ÷ 360 = 133 Amps + 25% for continuous duty.
    2. Fuses 150 Amp
    3. Disconnect 200 Amp

4. a. Motor # 4 7 1/2 HP
    1. Running current 430-150 22 + 10% = 24 Amps
    2. Running overcurrent 430-32 24 + 25% = 24 + 6 = 30 amps
    3. Branch circuit 430-22 24 + 25% = 24+6 = 30 Amps # 10 AWG
    4. Fuses - 430-152 1.50 x 24 = 36 Amps 40A Fuse - 60A Switch
    5. Disconnect 100 Amp

    b. Motor # 5 2 HP
    1. Running current 430-150 - 6.8 + 10% = 6.8 + .6 = 7.4 or 8 Amps
    2. Running overcurrent 430-32 = 8 + 25% = 8 + 2 = 10 Amps
    3. Branch circuit 430-22 8 + 25% = 8 + 2 = 10 Amps #14 AWG
    4. Fuses 430-152 1.5 x 8 = 12A or 15A Fuse - 30A Switch
    5. Disconnect 30 Amp

c. Motor # 6 5 HP

1. Running current 430-150 15.2 + 10% = 16.7 or 17 Amps
2. Running overcurrent 430-32 - 16.7 + 4.1 = 21 Amps
3. Branch circuit 430-22 17 + 25% = 17 + 4 = 21 amps #12? or 10 AWG
4. Fuses 430-152 - 300% = 17 x 3 = 51 Amps 50 Amp fuses
5. Disconnect 60 Amp

5. Motors 1, 2, & 3

a. Fuses 430-53 (c-4) 430-152 50A Fuse + 28A + 9.6A = 87.6A or 80A Fuse

b. Disconnect - 100 A

c. Branch circuit 430-54 100% of all load + 25% of largest motor load.
17 + 31 + 11 = 59 + 25% of 31 = 59 + 8 = 67 Amps # 4 AWG

6. Motors 4, 5, & 6

a. Fuses 430-53 (c-4) 430-152 50 A Fuse + 8A + 24A = 82A, or 80A Fuse
80 - 100 A Switch

b. Disconnect 100 Amp

c. Branch circuit 430-24 17 + 10 + (24 + 25%) = 27 + 30 = 57 Amps
# 6 AWG

7. Total combined load

Feeders 430-25

Motor	1. 17.0
	2. 31.0
	3. 11.0
Lights	67.0
Power	133.0
Motor	4. 24.0
	5. 8.0
	6. 17.0
25% of Motor	8
#2	316.0 Amps

400 MCM Feeders

Main Line Fuses
For 5HP Motor - 50A Fuse
+ 31A = 10HP
+ 11A = 3HP
+ 67A = Lts
+133A = Power
+ 24A = 7½HP Motor
+ 8A = 2HP
+ 17A = Other 5HP
341A or 300A Fuse
See 430-62(Says--
Not Greater, etc.)

Main Disconnect

400 Amp

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-20 THRU B-22
TEST B-5

5. Give three examples of "damp locations" which would require special construction:

(a) BASEMENTS
(b) BARNS
(c) COLD STORAGE WAREHOUSES

*ALTERNATE ANSWERS
* UNDER CANOPIES
* UNDER MARQUEES

6. Give three examples of "wet locations" which would require special consideration:

(a) SUBJECT TO SATURATION
(b) EXPOSED TO WEATHER
(c) INSTALLATIONS UNDERGROUND

*ALTERNATE ANSWERS
*VEHICLE WASHING AREAS
*IN CONCRETE SLAB IN DIRECT CONTACT WITH EARTH

7. How shall the fixtures installed in a clothes closet be located?

(a) ON WALL ABOVE THE CLOSET DOOR (410-8)
(b) ON THE CEILING

8. When is "feed-thru" wiring permitted in an outlet box which is an integral part of an incandescent fixture? WHEN THE FIXTURE IS APPROVED (LISTED) FOR "FEED-THRU" WIRING.

9. List the three requirements for a cord-connected electric discharge lighting fixture.

(a) CORD IS CONTINUOUSLY VISIBLE FOR ITS ENTIRE LENGTH
(b) CORD IS NOT SUBJECT TO STRAIN OR PHYSICAL DAMAGE
(c) CORD SHALL TERMINATE WITH A GROUNDING-TYPE PLUG

10. What three factors determine the type of wire used in a fixture?

(a) INSULATED FOR THE VOLTAGE
(b) CAPABLE OF CARRYING THE CURRENT
(c) INSULATED FOR THE TEMPERATURE TO WHICH THE CONDUCTORS WILL BE SUBJECTED

NAME ______________________________ TEST B-5

11. On a screw-shell lampholder, where do the wires connect?

(a) Phase conductor connects to the BRASS screw.

(b) Identified conductor connects to the WHITE screw.

(c) The IDENTIFIED conductor must connect to the screw-shell terminal screw.

12. Four of the most used conductor types for fixture channel wiring are:

(a) RHH (c) XHHW

(b) THHN (d) THW

13. All wiring shall be free from short CIRCUITS and GROUNDS and shall be TESTED for these defects prior to being connected to the CIRCUIT.

14. N. E. Code Section 410-67 (C) (2) requires "a suitable metal raceway" for recessed fixtures. Is "flex" metal conduit approved? Yes/No YES. Give the N. E. Code Section to prove your answer. 350-4 EXC-3

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-23 THRU B-26
TEST B-6

1. Maximum voltage permitted for lighting fixtures is 150 volts.

2. All non-current-carrying metal parts of a lighting fixture shall be GROUNDED.

3. Service drop conductors shall not be installed above swimming pools or within 10 feet of inside walls of pool, DIVING structure, observation STANDS, towers or PLATFORMS.

4. All pool equipment shall be GROUNDED to a common pool ground.

5. Metallic raceways shall not be depended upon for GROUNDING.

6. Transformers used to supply fixtures shall meet the following requirements:

   (a) APPROVED FOR THE LOCATION

   (b) HAVE TWO WINDINGS WITH GROUNDED METAL BARRIER BETWEEN PRIMARY AND SECONDARY WINDINGS

7. Non-metallic conduit used to feed wet-niche fixtures requires an insulated No. 8 AWG solid COPPER grounding conductor.

8. Are all components of a pool water heater required to be grounded? NO. Give the N. E. Code Section to justify your answer. 680-22 (c)

9. The filter pump of a storable pool is required to have double insulation and be effectively grounded. What other protective device is also required? GROUND-FAULT CIRCUIT INTERRUPTER

10. The five major items of equipment for crane power are:

    (a) COLLECTOR SWITCH

    (b) COLLECTOR CONTACT CONDUCTORS FOR MAIN

    (c) CAB MAIN-LINE SWITCH

    (d) COLLECTOR CONTACT CONDUCTORS FOR BRIDGE

    (e) MOTOR CIRCUIT WIRING

NAME ______________________________ TEST B-6

11. The maximum voltage permitted on A. C. system for control and signal circuits is 300 volts except where the maximum current is 8 MILLIAMPERES.

12. Travel cables shall be Type E, FO, or EN.

13. The minimum gauge traveling conductor permitted for lighting circuit is No. 20 AWG in parallel.

14. Raceway shall terminate a minimum of 6 inches above the floor.

15. Conductors of different systems may be installed in the same conduit provided all the conductors are insulated for the MAXIMUM VOLTAGE.

16. Wiring and equipment located under the car platform of a garage elevator shall be considered in a HAZARDOUS location.

17. A minimum working space of 24 inches shall be provided in the rear of an elevator control panel.

18. What five types of electrical services to a building would be connected to an emergency system?

(a) LIGHTING

(b) ESSENTIAL REFRIGERATION

(c) VENTILATION (WHEN ESSENTIAL) TO MAINTAIN LIFE

(d) CRITICAL INDUSTRIAL PROCESSES

(e) FIRE PUMPS

*ALTERNATE ANSWERS

* OPERATION OF MECHANICAL BREATHING APPARATUS

* POWER FOR OPERATING ROOMS

* FIRE ALARM SYSTEMS

19. How much capacity and rating should an emergency system have?

ADEQUATE FOR THE EMERGENCY OPERATION OF ALL EQUIPMENT CONNECTED TO THE SYSTEM

20. What device is used to switch the emergency system on? AN AUTOMATIC TRANSFER SWITCH

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-23 THRU B-26
TEST B-6

21. What types of emergency systems are covered in Article 700 - Emergency Systems? Name four of them.

(a) RECHARGEABLE BATTERY UNITS

(b) STORAGE BATTERY

(c) GENERATOR SET

(d) SEPARATE SERVICES

*ALTERNATE ANSWERS

* CONNECTION AHEAD OF SERVICE MAIN

* AUXILIARY SOURCE

22. What prohibits a dry-cell battery from being approved for emergency system power? THE DRY CELL BATTERY IS NOT A RECHARGEABLE BATTERY.

23. Service to a mobile home is always 115/230 (120/240) volts, 1 phase, 4 wire, 60 Hertz.

24. The service conductor to a mobile home can be: (Check the correct methods.)

X (a) Thru an overhead conduit mast

X (b) One or more approved cord assemblies

X (c) An approved underground feeder

___ (d) Open wiring on insulators

X (e) Permanent conduit connection

25. Does the "power take-off" outside the mobile home which feeds one of the service wiring methods in question # 24 to the mobile home have the designation of being the service equipment? Yes/No YES. Reference 550-4 (A)

26. Cord assemblies used for mobile home service power supply are rated 40 or 50 amperes, 250 volts, 4 wire, at least 21 feet long but not to exceed 36 1/2 feet overall.

27. What is the maximum number of power supply cords that may be used to serve a mobile home? 3

NAME ______________________________ TEST B-6

28. The cord and connection assembly for a mobile home is called a POWER SUPPLY CORD and for a recreational vehicle, it is called a POWER SUPPLY ASSEMBLY.

29. Explain how the Identified Conductor (Neutral) and the Equipment Grounding Conductor are terminated in a recreational vehicle.

THE NEUTRAL IS INSULATED FROM THE PANEL CAN. THE EQUIPMENT GROUNDING CONDUCTOR IS BONDED TO THE PANEL CAN. BOTH ARE TIED TOGETHER AT THE SERVICE EQUIPMENT REMOTE FROM THE VEHICLE.

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-1 THRU B-5
TEST B-1

1. Which phase (or leg) would be labeled as the "High Leg"? __________ What is its N. E. Code color coding? __________ List the N. E. C. Reference. ____________

2. What color coding is applied to the "Intentionally grounded" conductor of the transformer? __________ What is the common term for this conductor? ____________

3. List two ways to obtain 120 volt power in an installation using a three phase, "3 wire delta" service. (a) ____________________ or (b) ____________________

4. List four reasons for providing separate circuits for lighting loads and motor loads.

   (a) ____

   ____

   (b) ____

   ____

   (c) ____

   ____

   (d) ____

   ____

5. MATCH: Place the number representing the name of the Instrument in Column B on the line giving the use, Column A.

Column A	Column B
_____ a. An instrument used to measure VOLTAGE.	1. Ohmmeter
_____ b. An instrument used to measure POWER.	2. Ammeter
_____ c. An instrument used to measure CURRENT.	3. Voltmeter
_____ d. An instrument used to measure RESISTANCE.	4. Megameter
	5. Wattmeter

6. When using a Voltmeter to test a circuit, how should it be connected?

   ____

NAME ______________________________ TEST B-1

7. Give one main purpose of a "megger" or megameter.

____

____

8. What is a multi-meter? ____

____

9. Explain the "Bell" or "Buzzer" method for location and identifying conductors. ____

____

10. What are the two windings of a transformer called?

(a) ______________________ (b) ______________________

11. List three types of losses in a transformer:

(a) ______________ (b) ______________ (c) ______________

12. Basic construction of a transformer consist of the following:

(a) ______________________ (b) ______________________

(c) ______________________

13. List six main classifications of transformers:

(a) ______________________ (d) ______________________

(b) ______________________ (e) ______________________

(c) ______________________ (f) ______________________

14. The input of a transformer is the same as the output plus copper and iron losses. True/False __________

15. Find the percent regulation of a transformer which reads 575 volts secondary at no load and 550 volts secondary at full load.

Percent Reg. = $\frac{\text{No load sec. - full load sec.}}{\text{Full load sec.}}$

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-1 THRU B-5
TEST B-1

16. Match the capital letter on each of the following schematic drawings to the proper transformer description:

_____ Transformer having single primary winding and dual secondary windings, with secondary connected in series.

_____ Transformer having dual primary connected in series and dual secondary connected in parallel.

_____ Transformer having dual primary connected in series and dual secondary connected in series.

_____ Transformer having single primary and secondary windings.

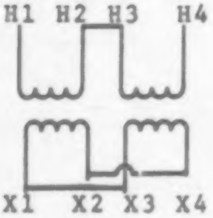
_____ Transformer connected additive polarity.

_____ Transformer connected subtractive polarity.

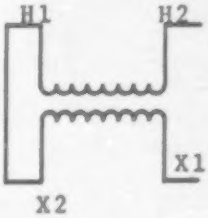
_____ Autotransformer.

_____ Transformer having dual primary connected in parallel and single secondary windings.

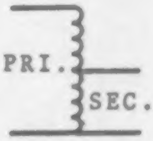
A.


H1
H2
H3
H4
X1
X2
X3
X4

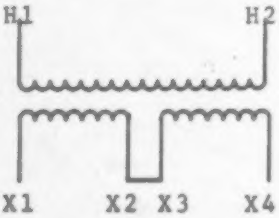
B.



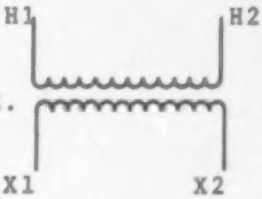
C.



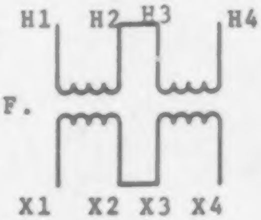
D.


H1
H2
X1
X2
X3
X4

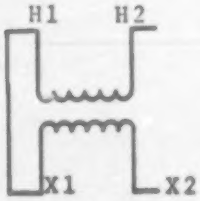
E.



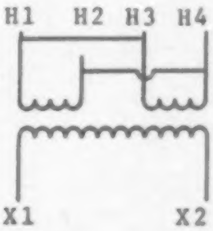
F.


H1
H2
H3
H4
X1
X2
X3
X4

G.



H.


H1
H2
H3
H4
X1
X2

NAME ______________________________ TEST B-1

17. The autotransformer is the most efficient and effective means of increasing or decreasing voltage. True/False ________

18. Coils of either a single phase or a three phase transformer may be connected for operating as an autotransformer. True/False ________

19. What three factors make the installation of a three-phase transformer more advantageous than a bank of single phase transformers operating as a unit?

(a) ______________________________

(b) ______________________________

(c) ______________________________

20. What two basic installation precautions should be followed in mounting any transformer?

(a) ______________________________

(b) ______________________________

21. List two reasons for connecting the primary and secondary neutrals in wye-wye connected transformers:

(a) ____

(b) ____

22. A three phase transformer is three __________ phase transformers connected in ____________ and enclosed in a single housing.

23. A step-up transformer ____________ the voltage and ______________ the current.

24. List two disadvantages of the open delta transformer connection:

(a) ____

(b) ____

25. Taps on a transformer are used for ______________ the voltage by a small amount - usually 2 1/2 % per step.

NAME ________________________________

DATE ________________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-6 THRU B-10
TEST B-2

1. What are the eight main types of fixed electric space heating equipment?

    (a) ____
    (b) ____
    (c) ____
    (d) ____
    (e) ____
    (f) ____
    (g) ____
    (h) ____

2. The size of branch-circuit conductors supplying fixed electric space heating equipment shall be sized on the basis of _______% of the total connected load.

3. The overcurrent protective device for the above branch circuit conductor must be sized for _________% of the total connected load.

4. The maximum overcurrent protection for resistance-type space heating equipment is ___ amperes. The maximum load shall not exceed _____ amperes.

5. The fan and duct heater circuits must be ________________ so the movement of air across the heater is assured.

6. The load for de-icing and snow-melting equipment is considered as __________________. This means the overcurrent protective device and the branch circuit conductor must be sized for ______% of the load.

7. Can the non-heating leads of de-icing and snow-melting equipment be shortened? Yes/No ______ Give the N. E. Code Section for your answer. ______________ Is this different from indoor ceiling and floor cable installations? Yes/No _____ Give the N. E. Code Section for your answer. _________________

8. The nominal covering for embedded cables is _______ inches below the surface.

NAME ______________________________ TEST B-2

9. The Code requires cables to be tested before ______________. The careful electrician will test the cable before installation, befor ______________, and ____________ covering.

10. The Code requires that conductors and equipment be approved. What is meant by approved? ____

____

11. Match Column A with Code Numbers in Column B.

	Column A	Column B
_____	(a) Manditory Rules	(1) 110-6
_____	(b) Circuit Voltage	(2) 110-8
_____	(c) Conductor Gages	(3) 110-5
_____	(d) Wiring Methods	(4) 110-3
		(5) 110-9

12. Give Code Section that tells how all equipment shall be installed.
_____________ How shall it be installed? _______________________

____

13. True or False - Mark T or F on line after statement and give Code references.

(a) All electrical equipment shall be identified by the manufacturer's name or trademark. ________ Reference ______________

(b) When the wiring system is completed, all wiring shall be free from short circuits and grounds. _______ Reference ____________

(c) The Code permits you to put a shelf (for storage purposes) across the front of a panel if it is a removable type. __________ Reference ________________

(d) All conductors shall be spliced or joined with approved splicing devices. _______ Reference ______________

(e) The Code permits the use of wooden pegs driven into holes in masonry walls to fasten electrical equipment to the wall. ______ Reference ________________

(f) If equipment operates at more than 50 volts, and not more than 600 volts is elevated at least 8 feet above the floor it does not need to have a guard over "live parts." _____ Reference __________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-6 THRU B-10
TEST B-2

14. All interior wiring systems shall have a grounded conductor. How is this conductor identified? ______________________________

15. In cable wiring, what section of the N. E. Code allows the identified conductor (white wire) to be used as the "return conductor" from the switch to the outlet? ______________________________

16. Grounded conductor shall be connected to ______ - ______ terminal.

17. Identified conductor shall be connected to identified ________ colored terminal to screw-shell.

18. Grounded terminal shall be identified by ______ ________ coating.

19. The equipment grounding conductor terminal on the receptacle shall be __________ color.

20. The grounded circuit conductor terminal on the receptacle shall be ___________ color.

21. List two types of grounds used in an interior wiring system.

    (a) ______________________________

    (b) ______________________________

22. The minimum copper grounding conductor for an A.C. system shall be No. _____ AWG.

23. The maximum copper grounding conductor required for an A. C. system is No. ______ AWG.

24. The resistance of made electrodes shall not exceed _____ ohms.

25. The minimum length of buried metallic water piping system permitted as a grounding electrode shall be ______ feet.

26. In general, underground water pipes have a resistance to ground of less than ______ ohms.

27. All portable tools shall be ____________.

28. Service entrance conduit shall be ____________.

NAME ______________________________ TEST B-2

29. Metal frame constructed building shall be ______________.

30. List at least five approved types of grounding electrodes.

(a) ____

(b) ____

(c) ____

(d) ____

(e) ____

NAME ____________________

DATE ____________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-11 Thru B-16
TEST B-3

1. Where conductors of different systems are installed in the same gutter or raceway, handling more than one identified conductor, how shall they be marked? ____

____

Reference ________________________

2. (a) What section of the Code covers ground-fault circuit protection on 15 and 20 ampere receptacle outlets on single phase circuit at construction sites? ________________________________

3. Give minimum size copper conductor for the following branch circuit classification (75°C).

   (a) 15 ampere branch circuit ________________

   (b) 20 ampere branch circuit ________________

   (c) 30 ampere branch circuit ________________

   (d) 65 ampere branch circuit ________________

4. The Code requires additional receptacles above the 200 watts per ft.

   (a) Give Section __________________

   (b) Where are they located? ____

   ____

5. What is a multiwire branch circuit? ______________________________

____

Reference Code ______________________

NAME ______________________________ TEST B-3

6. What is meant by:

(a) Fixed appliance? ______________________________

(b) Portable appliance? ______________________________

(c) Stationary appliance? ______________________________

7. What are the Branch Circuit requirements for small appliances in a residence? ______________________________

8. Does the Code require you to put a laundry circuit in all dwellings? ______ Give Code Section to back up answer. ______________

9. Is it permissible to load a circuit to its capacity with portable or stationary appliances? ______

10. When there is a protective device rating marked on appliance, is it permissible to use a larger branch circuit overcurrent device? ______________

11. Name the five basic items that should be included in a feeder diagram.

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

(e) ______________________________

12. Give Unit Load per square ft. for General Lighting Load that applies to the following:

	Answer	References
(a) Banks	______	__________
(b) Court Rooms	______	__________
(c) Office Building	______	__________
(d) Dwellings (other than Hotels)	______	__________
(e) Schools	______	__________
(f) Restaurants	______	__________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-11 THRU B-16
TEST B-3

13. How many circuits would be required for General Lighting in a dwelling having 2100 square ft.? ____________. Give Code Section reference. ________________

14. When calculating load for a dwelling, is the demand factor applied to the 2 kitchen and laundry circuits? ____________________________ ____________________________
Reference ______________

15. When computing the square footage of a building for a general lighting load, what dimensions are used? ______________ Code Section Ref. ____________________

16. What does the service consist of? ______________________________ ________________________ Reference ____________________________

17. (a) What is meant by service drop conductors? ______________ ______________________________ ______________________________ ______________________________

(b) What is meant by service-entrance conductors? ______________ ______________________________ ______________________________ ______________________________

18. Must there be means to disconnect the grounded conductor from the interior wiring, at the service disconnect switch? _____ Give Code Section Reference. __________________

19. Service equipment enclosures _______ be grounded. (Should or Shall) Give Code Section. ____________

20. Define a Master Service. ______________________________ ______________________________

Give your reference. ______________________________

21. Article 305 of the N. E. Code sets the requirements for temporary wiring. True/False _______ Reference or Reason ______________

22. Temporary wiring can only be used for 90 days for any type temporary installation. True/False _________
Reference or Reason ______________________________

NAME ______________________________ TEST B-3

23. Ground-fault circuit protection is required for all 15 and 20 ampere receptacle outlets. True/False. __________
Reference or Reason ____

24. Can a two-wire 120 volt 15 ampere receptacle be used as an outlet for a 1/4 H. P. drill motor on a construction site? Yes/No ______
Reference or Reason ____

25. Does every branch circuit which supplies receptacles or fixed equipment have to contain a separate equipment grounding conductor? Yes/No. _______

26. A 3/4 inch diameter by 10 foot copper-clad ground rod is approved as an earth return for a receptacle which has no equipment grounding conductor in the circuit feeding the receptacle. True/False ______
Reference or Reason ____

27. Give the minimum size conductors for the following:

(a) Overhead spans ____
____

(b) Festoon lighting ____
____

(c) Over 600 volts ____
____

28. What is minimum separation of conductors exposed to weather? Also support bracket separation?

1. ____
2 ____
3. ____
____

29. What are the minimum clearances in feet of open conductors not over 600 volts?

(a) Above finish grade ______________
(b) Residential driveways ______________
(c) Parking lots not subject to truck traffic ______________
(d) Public streets ______________
(e) Over roof ______________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-17 THRU B-19
TEST B-4

1. What are the three principal types of D. C. motors?
   (a) ______________________________
   (b) ______________________________
   (c) ______________________________

2. The speed of D. C. motors can be controlled by what two general classifications?
   (a) ______________________________
   (b) ______________________________

3. The actual effective voltage in an armature of a D. C. motor is the ______________ voltage less the ____________________.

4. Shunt motors are considered as ___________________ speed motors.

5. Series motors are considered as ____________ speed motors.

6. To generate electricity, there must be a relative motion between a ______________ and a ______________ field.

7. In D. C. generators, the armature is always the _________. In most A. C. generators, the armature is __________________.

8. In a 3 Ø "wye" or "star" alternator, the line voltage across any two line levels is the __________ __________ of the individual phase voltages. The line voltage is __________ times the phase voltage. Line and phase currents are __________.

9. In a 3 Ø "delta" alternator, the line voltages are _______ to the phase voltage, but the line currents will be equal to the ____________ _______ of the phase currents. The line current will be ____________ times the phase current.

10. The starting _________ has a _________ resistance than the running winding of a split-phase motor, thus the interaction of the rotating magnetic field provides a starting _________ for the motor.

11. The angular phase displacement in a split-phase motor is approximately _______ to 30 degrees in time.

12. Overheating of the winding insulation may be caused by _____ _________, ________ ____________, and _______ _________ currents.

NAME ______________________________ TEST B-4

13. Two-speed split-phase motors have _____ sets of windings, _____ _____ for each speed.

14. Permanent _______ ___________ motors are used for fans and blowers.

15. In a repulsion motor, the ________ poles are repelled by the ________ poles causing the _________ to rotate.

16. The ______________________ motor operates on A. C. or D. C. circuits.

17. The _____________ is connected in series with the _______ in a universal motor.

18. List two types of universal motors:

(a) _________-_____________________

(b) __________________ ____________

19. The _________________ universal motor has an extra winding embedded in the poles of the starter.

20. The ______________ universal motor is a low-horsepower motor operating at __________________ speeds.

21. List the three major types of three-phase motors:

(a) ____

(b) ____

(c) ____

22. In a three-phase motor, the windings are _______ electrical degrees apart.

23. List two methods of connecting a three-phase motor stator to a three phase power source.

(a) _____________

(b) _____________

24. The __________ - _______ motor operates on the induction principle.

25. List the four conditions which regulate the speed of a squirrel-cage motor:

(a) ___________________________ (c) _____________________________

(b) ___________________________ (d) _____________________________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-17 THRU B-19
TEST B-4

26. The squirrel-cage motor is considered to be a __________ - __________ type.

27. In a wound-rotor motor, the starting _______ and current, _____ load and ______ of the motor can be controlled.

28. The wound-rotor motor is used for equipment having constant ________ ________ and __________ ___________ up to full-rated load.

29. The two windings of three-phase induction motors are located in the ________ and _________.

30. List two important characteristics of a synchronous motor:

(a) ______________________________

(b) ______________________________

31. What type motor is used to transmit information in the form of electrical signals? ___________________

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-20 THRU B-22
TEST B-5

1. Explain what the N. E. Code means when it specified that some equipment shall be "in sight from" another equipment.

____

____

2. List the information that should be on the name plate of a motor:

(a) ____

(b) ____

(c) ____

(d) ____

(e) ____

(f) ____

(g) ____

(h) ____

(i) ____

(j) ____

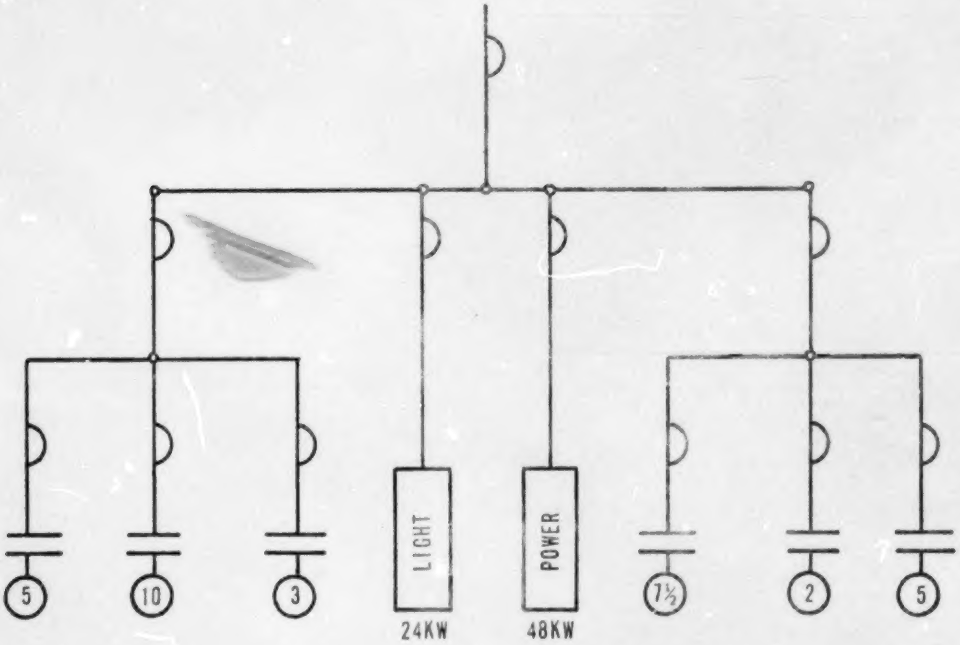
3. What are the three types of motor circuit conductors? Give the N. E. Code Section for each type.

	Types	Code Section
(a)	______________________	____________
(b)	______________________	____________
(c)	______________________	____________

NAME ______________________________ TEST B-5

4. PROBLEM: Using the National Electrical Code as reference, find the following for the electrical system below rated 120/208 volts, three phase, four wire:

a. Minimum feeder size
b. Maximum feeder overcurrent protection
c. Minimum branch circuit conductors
d. Maximum branch circuit overcurrent protection
e. Maximum motor-running overcurrent protection



NOTE: All motors 3 Ø with 40° C. rise.
Use code letter "F" for 5 HP motors.
Use code letter "A" on the other motors.
Use 75° centigrade wire temperature (copper).

NAME ______________________________

DATE ______________________________

ELECTRICAL APPRENTICE
TECHNICAL TRAINING
SECOND YEAR - SERIES B
LESSON B-20 THRU B-22
TEST B-5

5. Give three examples of "damp locations" which would require special construction:

(a) ____________________________

(b) ____________________________

(c) ____________________________

6. Give three examples of "wet locations" which would require special consideration:

(a) ____________________________

(b) ____________________________

(c) ____________________________

7. How shall the fixtures installed in a clothes closet be located?

(a) ____________________________________

(b) ____________________________________

8. When is "feed-thru" wiring permitted in an outlet box which is an integral part of an incandescent fixture? ________________________

____

9. List the three requirements for a cord-connected electric discharge lighting fixture.

(a) ____

(b) ____

(c) ____

10. What three factors determine the type of wire used in a fixture?

(a) ____

(b) ____

(c) ____

____

NAME ______________________________ TEST B-5

11. On a screw-shell lampholder, where do the wires connect?

    (a) Phase conductor connects to the ________ screw.

    (b) Identified conductor connects to the _______ screw.

    (c) The ____ __________ conductor must connect to the screw-shell terminal screw.

12. Four of the most used conductor types for fixture channel wiring are:

    (a) __________________ (c) ________________

    (b) _________________ (d) ________________

13. All wiring shall be free from short ___________ and __________ and shall be _________ for these defects prior to being connected to the __________ __.

14. N. E. Code Section 410-67 (c) requires "a suitable metal raceway" for recessed fixtures. Is "flex" metal conduit approved? Yes/No ____. Give the N. E. Code Section to prove your answer. ___________

NAME ______________________________

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1. Maximum voltage permitted for lighting fixtures is _____ volts.

2. All non-current-carrying metal parts of a lighting fixture shall be ____________.

3. Service drop conductors shall not be installed above swimming pools or within ____ feet of inside walls of pool, _________ structure, observation _________, towers or _____________.

4. All pool equipment shall be __________ to a common pool ground.

5. Metallic raceways shall not be depended upon for _____________.

6. Transformers used to supply fixtures shall meet the following requirements:

   (a) ____

   (b) ____

   ____

7. Non-metallic conduit used to feed wet-niche fixtures requires an insulated No. _____ AWG solid ____________ grounding conductor.

8. Are all components of a pool water heater required to be grounded? _________. Give the N. E. Code Section to justify your answer. ______________

9. The filter pump of a storable pool is required to have double insulation and be effectively grounded. What other protective device is also required? ______________________________

10. The five major items of equipment for crane power are:

   (a) ____

   (b) ____

   (c) ____

   (d) ____

   (e) ____

NAME ______________________________ TEST B-6

11. The maximum voltage permitted on A. C. system for control and signal circuits is ________ volts except where the maximum current is ____ __________________.

12. Travel cables shall be Type ____, ______, or ______.

13. The minimum gauge traveling conductor permitted for lighting circuit is No. ______ AWG in parallel.

14. Raceway shall terminate a minimum of _____ inches above the floor.

15. Conductors of different systems may be installed in the same conduit provided all the conductors are insulated for the ____________ ______________.

16. Wiring and equipment located under the car platform of a garage elevator shall be considered in a ____________ location.

17. A minimum working space of _____ inches shall be provided in the rear of an elevator control panel.

18. What five types of electrical services to a building would be connected to an emergency system?

(a) ______________________________

(b) ______________________________

(c) ______________________________

____

(d) ______________________________

(e) ______________________________

19. How much capacity and rating should an emergency system have?

____

____

20. What device is used to switch the emergency system on? ___________

____

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21. What types of emergency systems are covered in Article 700 - Emergency Systems? Name four of them.

(a) ______________________________

(b) ______________________________

(c) ______________________________

(d) ______________________________

22. What prohibits a dry-cell battery from being approved for emergency system power? ______________________________

____

23. Service to a mobile home is always ____________________ volts, _____ phase, ______ wire, _______ Hertz.

24. The service conductor to a mobile home can be: (Check the correct methods.)

_____ (a) Thru an overhead conduit mast

_____ (b) One or more approved cord assemblies

_____ (c) An approved underground feeder

_____ (d) Open wiring on insulators

_____ (e) Permanent conduit connection

25. Does the "power take-off" outside the mobile home which feeds one of the service wiring methods in question # 24 to the mobile home have the designation of being the service equipment? Yes/No _______. Reference _______________

26. Cord assemblies used for mobile home service power supply are rated ____ or ____ amperes, ______ volts, _____ wire, at least ____ feet long but not to exceed _________ feet overall.

27. What is the maximum number of power supply cords that may be used to serve a mobile home? __________

NAME ______________________________ TEST B-6

28. The cord and connection assembly for a mobile home is called a ______________________ and for a recreational vehicle, it is called a ______________________.

29. Explain how the Identified Conductor (Neutral) and the Equipment Grounding Conductor are terminated in a recreational vehicle.

____

____

____